POWER

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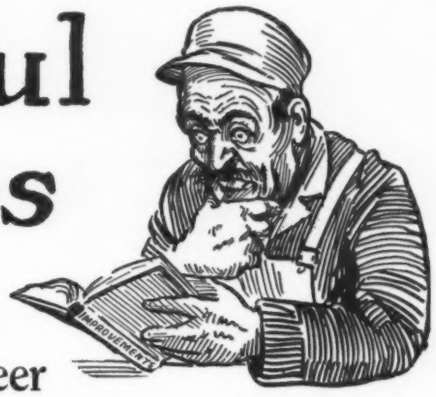
Purposeful Anecdotes

Uptodate Knowledge for the Uptodate Engineer



IT was in one of those old-fashioned factories, with an old-fashioned boss and old-fashioned machinery and ways. The engine had been running for years—so many that people had almost forgotten when it started. Men had come and men had gone, but the old engine went on forever.

One morning, however, there was a "rift in the lute which made the noisy music mute" (of the engine). One of the valve rods on the walking beam broke. The engineer reported it to the boss, and he, with a look of indignation, exclaimed: "Why, Bill, what have you been doing? That engine has been running for about forty years and that rod never broke before."

Well, what has this to do with POWER? you will ask.

Just this—The training you got when you were a boy firing that old boiler with the high pressures of fifty pounds or so will not do for you today, nor when you advanced to the higher position of engine tender with that old beam engine and were looked upon as the great and only village wizard by your admiring friends.

You remember those days—with what stately pride you walked into the domain of the engine room and opened a valve, and behold, as if by magic, the shafting began to turn!

You remember also that, should the engine stop, you would come, look, and after some wonderful sleight-of-hand performance the engine was doing its required work. You remember, after you had learned the elements of the indicator, how you walked down the street past the village square, with the Richards indicator box, and how you were respected. People said, "Look! That is our engineer at the factory."

Well, just take the advice of one who has been through the mill. If you are trying to hold a position worth while with the knowledge you got in those old days alone, like the engine-valve rod, some day you will find it too weak.

It may last for a while but it will not hold out forever.

MORAL

You cannot hold your job or obtain a better one without reading and studying uptodate engineering matter.

Contributed by ROBERT MAWSON, *New York*

Warren State Hospital Power Plant

By Warren O. Rogers

SYNOPSIS—An instance of an uneconomical power plant being displaced by one of modern design that, it is estimated, will pay for itself in about six years. Coal is stored in the boiler house and is handled by a traveling crane and grab bucket from the storage space to the stoker hoppers. The number and size of the boilers were selected with a view to reliability, flexibility and economy. Three are equipped with mechanical stokers and one is hand fired.

AN EXAMPLE of what a properly designed power plant can save in operating expenses over one not suitable for the demands made upon it is at the State Hospital for the Insane, Warren, Penn., where the newly completed central heating and power plant that has been constructed at a cost of $125,000 will, it is estimated, pay for itself in the course of five or six years, because of its high efficiency. The institution cares for insane patients from the northwestern part of the state on an 850-acre reservation, the buildings being located at various points to suit the requirements. The principal group served by the new power house, is within an area approximately 1750 ft. in a north and south direction by 1400 ft. in an east and west direction. Fig. 1 is a map of the buildings and grounds; as shown, the old power plant is about in the center of this group. Here the light and power were generated for all of the hospital buildings. The main building, greenhouses, laundry and men's bathhouse were heated from the old power house, but the remaining buildings of the main group were heated locally by cast-iron boilers burning either natural gas or anthracite coal.

The old plant contained three 200-hp. and one 250-hp. water-tube boilers, one 75-hp. and one 100-hp. gas engine of the vertical type. These units are not now used, and all steam, light and power is supplied by the new station. The fuel used in the boiler furnaces was, successively, natural gas, oil and lump bituminous coal. It was necessary to cart the coal from the siding to the old boiler house,

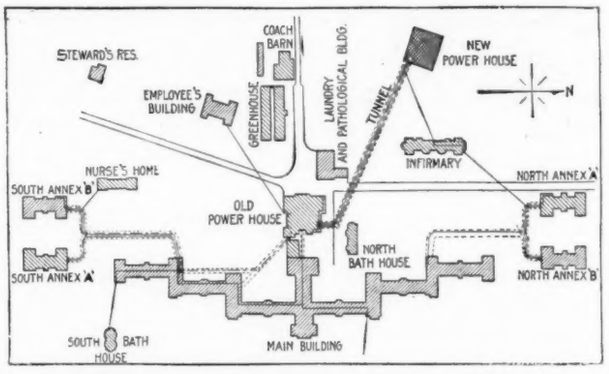


FIG. 1. MAP OF BUILDINGS AND GROUNDS

a distance of about 1000 ft. This increased the cost per ton, although this work was largely performed by certain of the inmates.

A list of buildings included in the main group and the approximate maximum boiler horsepower required to heat each follows:

	Maximum Boiler Hp. Required	
Buildings Heated from Old Power House		
Main building	660	
North men's bathhouse	21	
Old power house	20	
North greenhouse	42	
South greenhouse	37	
West greenhouse	15	
Laundry and pathological building	27	
Total		822
Buildings Heated by Cast-Iron Boilers		
North annex building A	40	
North annex building B	40	
South annex building A	40	
South annex building B	40	
South women's bathhouse	19	
Nurses' home	22	
Employees' building	35	
Infirmary	42	
Total		278
Total maximum boiler hp.		1100

Estimated Maximum Quantity of Steam Required for Other Purposes Than Heating		
Laundry	100	
Main building (engines driving ventilating fans)	40	
Domestic hot water for all buildings in group	300	
Auxiliaries	60	
Total		500
Total maximum boiler horsepower required for all purposes		1600

The total annual cost of fuel to furnish the steam required by the institution amounted to nearly $40,000. The annual cost with the new plant will be about $20,000.

The superintendent, Dr. H. W. Mitchell, who has been responsible for many desirable changes in the management

FIG. 2. EXTERIOR VIEW OF THE NEW POWER HOUSE

of the institution, was convinced soon after taking charge that the existing plant was uneconomical and that a new one would be a paying investment. It is owing to his exertion that the new power house has been built. After an investigation made by the consulting engineer for the hospital, J. E. Woodwell, 8 West Fortieth St., New York

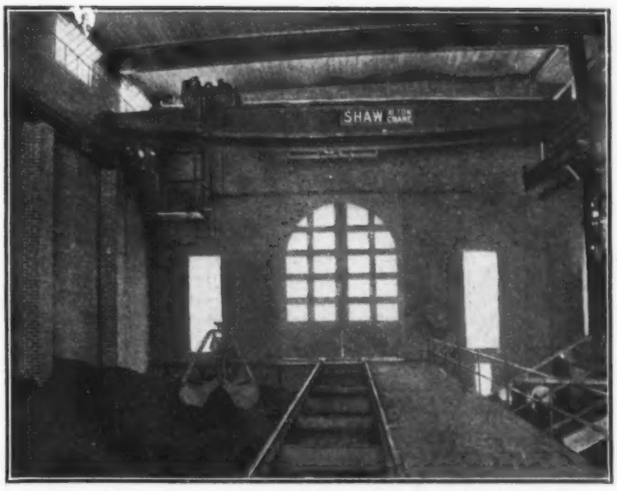


FIG. 4. CRANE IN BOILER ROOM AND GRAB BUCKET FOR HANDLING COAL FROM STORAGE TO STOKERS

City, it was decided that the annual fuel cost could be reduced about one-half by building a modern power plant close to the railroad, where the coal could be unloaded from the cars into a storage space to be located in the boiler house. It was estimated that the new station, together with a tunnel between it and the old plant, a distance of about 600 ft., would cost $125,000. This included the connections ready for service to all of the principal buildings in the group, moving some of the old apparatus from the old to the new power house, the installation of the necessary electric feeders and steam mains, etc.

The Pennsylvania Legislature, during the winter of 1912 and 1913, appropriated the necessary $125,000. Plans and specifications for the work were prepared during the summer of 1913 and the new plant and its equipment, together with the other new work and changes were completed and ready for service early in the fall of 1914.

New Power-House Building

An exterior view of the new power plant is shown in Fig. 2 and that of the old plant in the initial-letter illustration. The foundations of the new plant are of con-

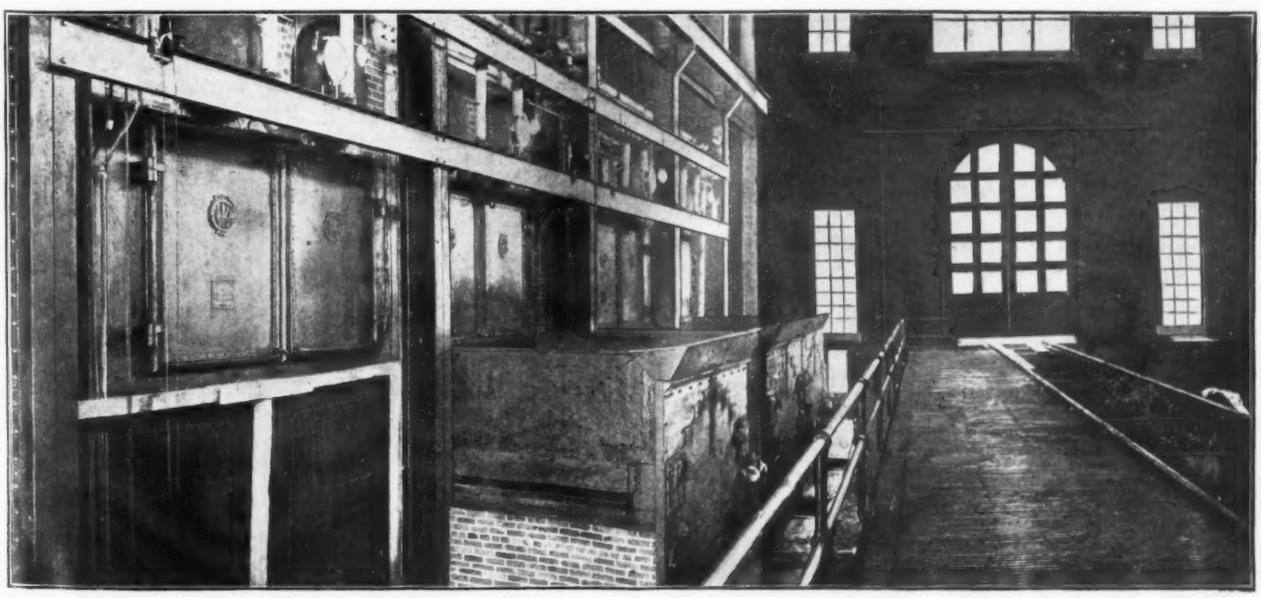


FIG. 3. VIEW OF BOILER ROOM AND COAL STORAGE SPACE LOOKING SOUTH

crete, the walls are of brick and the flat roof is laid according to Barrett specifications. This construction cut the cost 25 per cent. under any other suitable roof that would conform to the spacing of the bays. The under woodwork consists of 2x4-in. planking laid edgewise on I-

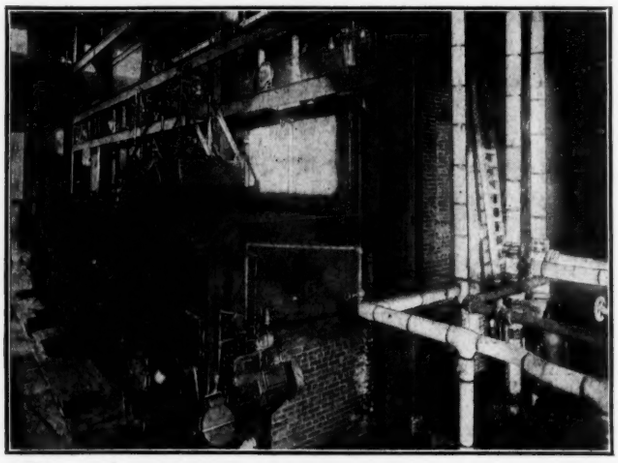


FIG. 5. BOILER FRONTS AND STOKERS. GRAB BUCKET DISCHARGING TO STOKERS

beam girders. The building is 96 ft. 6 in. by 109 ft. 6 in. The roof over the engine room is 27 ft. 2 in. and over the boiler room and coal-storage space is 38 ft. high.

Details of Boiler-Room Arrangement

The boiler plant consists of four water-tube boilers, each containing 4531 sq.ft. of heating surface, equivalent to a normal rating of 453 hp. and designed for a working pressure of 200 lb. Three of the boiler furnaces are equipped with mechanical stokers and one with shaking hand-fired grates. The stoker-grate surface has a width of 11 ft. 2 in. and a length of 7 ft. 2 in., giving an area of 80 sq.ft. This gives a ratio of 56.64 sq.ft. of heating surface to 1 sq.ft. of grate area. These stokers are set with the lower end of the grates 76 in. below the top of the firebrick arch. They are capable of developing from 60 to 100 per cent. in excess of the normal rating of the boilers.

All boiler furnaces operate under natural draft, the flue gases going to a radial-brick chimney 185 ft. high and having an inside diameter at the top of 9 ft. It is outside the building (Fig. 2) and is connected to the boiler uptakes by a brick-lined steel smoke flue, which for a distance of 35 ft. above the hand- and first stoker-fired boiler is 5 ft. wide and 10 ft. high, giving a sectional area of 50 sq.ft. At the third boiler the flue gradually enlarges until it is 8 ft. wide and 10 ft. high above the fourth boiler, or a cross-sectional area of 80 sq.ft. The connection at the chimney is 6 ft. 5 in. by 11 ft. 11 in. An expansion joint is placed in the flue between the fourth boiler and the chimney. The smoke duct is suspended from the roof girders and connects with the boiler uptakes at the bottom. A view of the boilers and storage space is shown in Fig. 3.

The number and sizes of the boilers were selected with a view to reliability, flexibility and economy in operation. At certain seasons of the year the steam consumption is light, so much so at times that one boiler is sufficient to carry the load with the stoker operated at less than half capacity, which is uneconomical. Because of this condition the hand-fired boiler is held as a reserve, to be used when the load is light or where there is a little more than one boiler can carry and not enough for two stoker-fired units under economical operation. It also stands ready to carry the load in case the stoker engine becomes disabled.

The boiler house can easily be extended and additional boilers installed and connected to the existing pipe line without changing the system.

Concrete ash hoppers receive the ashes from the stokers and discharge through gates into an industrial ashcar of the side-dumping type, from which they are dumped into a storage bin at the end of the coal-storage space, holding three railway-car loads. When a sufficient quantity has collected the ashes are hoisted by a motor-operated grab bucket and loaded into railroad cars to be hauled away for filling-in purposes. The ashes can also be discharged into a chute for loading into wagons.

Storage space is provided in front of the boilers for 1500 tons of coal. A track runs above the bins and the cars are unloaded through the bottom. As shown in Fig. 4, a 10-ton electric bridge crane spans the coal bins and the mechanical stokers. It carries a motor-operated clamshell grab bucket of 1½ cu.yd. capacity, and is used to handle the coal to the stokers (Fig. 5) in about one-ton quantities from any part of the storage space or from a loaded car. The same bucket is also used to handle the ashes from the ash bin to empty railroad cars, and for trimming either coal or ashes in the bunkers. In case it is desired the bucket can be removed and the crane used for hoisting purposes. With this arrangement no coal

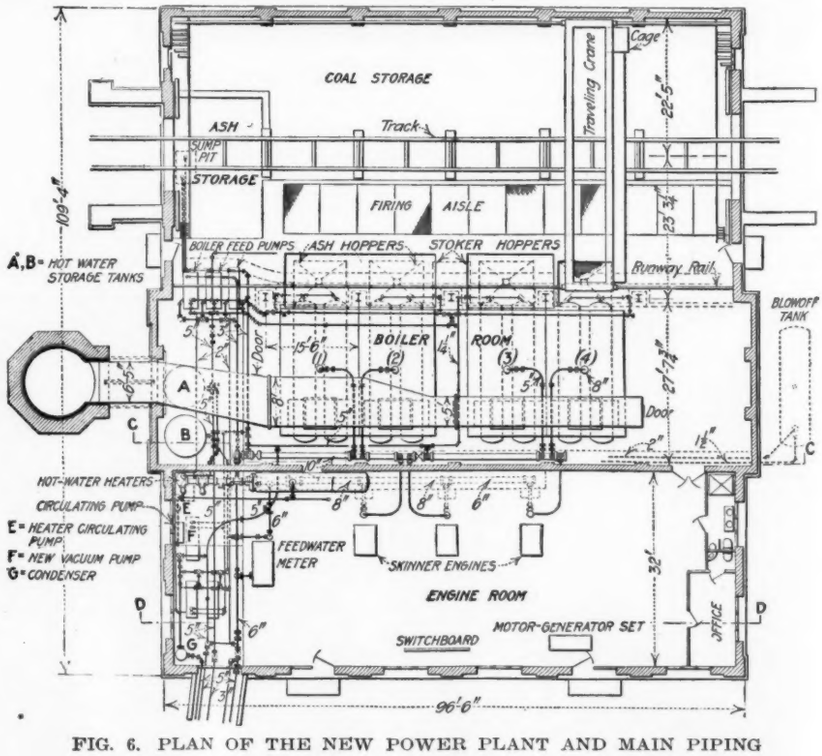


FIG. 6. PLAN OF THE NEW POWER PLANT AND MAIN PIPING

or ashes are handled by hand labor. A plan and elevation of the power plant are shown in Figs. 6 and 7.

Boiler feed is supplied by a new 12x8¼x14-in. simplex pump at the south end of the boiler room. There are also two duplex pumps formerly used in the old plant; these are installed on the boiler-room floor in front of the two water-storage tanks. Boiler water is passed through a V-notch integrating and recording feed-water meter that has a capacity of 75,000 lb. of water per hour. It is at the south end of the engine room and in front of the pump pit. The piping is arranged to supply the meter with water from an overhead return tank, from the main return pipe or from the hot-water supply tanks.

All return water of condensation and the necessary makeup water goes to the overhead tank in the engine room and flows by gravity to the feed-water meter through a 6-in. line. A 6-in. suction line runs from the meter to the feed pumps, and a 6-in. bypass connection is provided at the heater. Water is pumped from the feed pumps to the boilers through either a 3-in. main or a 3-in. auxiliary feed pipe with branches connecting to each boiler.

A sump pit for draining the coal- and ash-storage bins is provided with a motor-driven volute pump having a capacity of 60 gal. of water per min. against a head of 20 ft. The discharge is to a sewer.

There are three 12x12-in. center-crank engines, directly coupled to 62½-kw. direct-current 110 -220-volt generators, running at 280 r.p.m. These units supply light and power for the main buildings. On the opposite side of the room is a 31-hp. 220-volt motor-driven alternating generator set. The generator is a 20-kw. capacity 2200-volt single-phase 60-cycle unit at 800 r.p.m. and supplies energy for lighting several buildings, situated at such a distance that direct current could not be economically used. A six-panel switchboard, placed at one side of the room, is for generator and motor control. The distributing board is in the old power plant, the two boards being

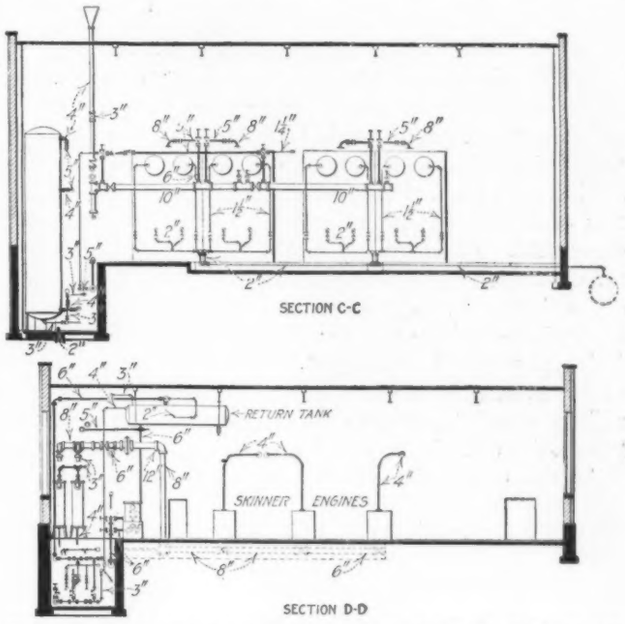


FIG. 7. ELEVATION OF ENGINE AND BOILER ROOMS OF THE POWER PLANT

connected by main cables that are run in the tunnel connecting the two stations. At the north end of the engine room is the engineer's office, also a lavatory.

The engine room can accommodate a large increase in generating capacity, and the present units can care for double their present load.

PRINCIPAL EQUIPMENT OF THE WARREN, PENN., STATE HOSPITAL POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Cost	Maker
4	Boilers	Geary water-tube	4531 sq.ft. heating surface	Steam generators	Three-stoker, one hand-fired.	$21,355.00*	Oil City Boiler Works
3	Stokers	Detroit	80 sq.ft. grate surface	Boiler furnaces	Engine-driven	4,500.00	Detroit Stoker Co.
1	Grate	Shaking		Boiler furnaces	Hand-fired		McClave-Brooks Co
1	Chimney	Radial-brick	185 ft. high, 9 ft. inside dia. at top	Furnace gases	Natural draft	6,630.00	Alphons Custodis Chimney Construction Co.
1	Crane and bucket	Bridge, Shaw	10-ton, 1-ton bucket	Coal and ash handling	Electrically operated	4,235.00	Shaw Electric Crane Co., supplied by Manning-Maxwell & Moore
1	Smoke duct	Steel, brick-lined	5x10 ft., 8x10 ft. and 6 ft., 5 in. by 11 ft., 11 in.	Between boilers and chimney	Brick, lined	1,571.00	Hammond Iron Works
1	Building	Brick	96 ft., 6 in. by 109 ft., 4 in.	Power house		38,910.74	Henry Shenk Co.
1	Tunnel	Concrete-lined	8 ft. wide, 7 ft. high, 590 ft., 6 in. long	Connecting old and new plants	For steam, water and return pipes and electric cables	10,564.31	Henry Shenk Co.
1	Motor	Direct-current	2-hp	Driving 2½-in. volute pump	230 volts, 1100 r.p.m.		Imperial Motor Co.
1	Pump	Volute	2½-in	Circulating water from storage tanks to heating system	1100 r.p.m., motor-driven, 200 gal., 5-ft head	With piping cost	Lawrence Pump & Engine Co.
1	Motor	Direct-current	3-hp	Driving 1-in. volute pump	230 volts, 1700 r.p.m.		Imperial Motor Co.
1	Pump	Volute	1-in	Circulating water from heater to storage tanks	1700 r.p.m., motor-driven, 25 gal. cap., head 90 ft		Lawrence Pump & Engine Co.
2	Tanks	Storage	78 in. dia., 32 ft. high	Hot water storage	Temperature of water automatically controlled	2,439.00†	Struthers-Wells Co.
1	Tank	Return	42-in. dia, 18 ft. long	Return condensate	Pump filled, gravity discharge	With piping cost	Alberger Pump & Condenser Co.
2	Heaters	Exhaust-steam	5000 gal. per hr	Heating domestic water	Using exhaust steam		M. T. Davidson
1	Pump	Simplex	12x8¼x14-in	Boiler feed	Variable speed		Henry R. Worthington
2	Pumps	Duplex		Boiler-feed auxiliaries	As required		Skinner Engine Co.
3	Engines	Skinner	12x12-in	Driving d.-c. generators	280 r.p.m., 150 lb. pressure	From old plant	Westinghouse Electric & Mfg. Co.
3	Generators	Direct-current	62½-kw	Generating units	Engine-driven, 280 r.p.m.		
1	Meter	V-notch, integrating and recording	75,000 lb. water per hour	Measuring feed water		With piping cost	Harrison Safety Boiler Works
1	Motor	Direct-current	1½-hp	Driving 2-in. pump	230 volts, 1000 r.p.m.		Imperial Motor Co.
1	Pump	Volute	2-in	Draining sump pit	Motor-driven, 1000 r.p.m.		Lawrence Pump & Engine Co.
1	Motor	Direct-current	31-hp	Driving alt. generator	220 volts, 900 r.p.m.		Westinghouse Electric & Mfg. Co.
1	Generator	Alternate current	20-kw	For distant lighting	Motor-driven, 900 r.p.m., 2200 volts, 1-phase, 60-cycle	From old plant	Westinghouse Electric & Mfg. Co.
1	Pump	Vacuum	10x16x18-in	Handling return water	General use		Blake & Knowles Steam Pump Co.
2	Pumps	Vacuum	10x12x12-in	Handling return water	Reserve units		Blake & Knowles Steam Pump Co.
	Piping and auxiliaries					21,486.00	W. K. Mitchell & Co., Inc.
	Miscellaneous, gages, alterations to switchboard and consulting engineers fees					10,989.65	
	Electric cables					2,319.30	General Electric Co.

* Includes bonus. † Includes platforms, etc.

Some Advances in Electricity

SYNOPSIS—A review of electrical progress during the past forty years, and some of the largest pieces of electrical apparatus now in use.

In the 40-yr. period marked by two great expositions—the Centennial at Philadelphia in 1876 and the Panama-Pacific International Exposition, progress in the application of electricity has undoubtedly exceeded that in any other field. Although much laboratory work and a few practical applications had previously been made, the time of the Centennial Exposition may be said to have witnessed the beginning of the commercial application of electricity. It is not proposed to describe here the electrical exhibits at the present exposition, as the purpose of the review will be served better by considering some of the actual installations which are in daily operation.

At the Centennial Exposition the electrical exhibits were few, consisting principally of Gramme dynamo-electric machines, a Farmer machine, a few primary batteries, and some telegraphic instruments. That the possibilities of electricity were not then fully appreciated, even by authorities in that field is shown by the report of the judges, which says in part: "The electro-magnetic machine has important practical application in the development of electricity for electroplating, electrotyping, for lighthouse uses and other purposes of intense illumination. The magneto-electrical machine, however, does not transmit and apply power without great loss of original energy." This conservatism is not strange when it is recalled that the Gramme machine, the most efficient of the half dozen types then in existence, had an efficiency of only 38 per cent. in contrast with 97 per cent. shown by some of the large alternators of the present day. This year (1876) also witnessed the invention of the telephone.

While some progress had been made with the electric arc, notably by a Russian named Jablochkoff, little was done with electric lighting in this country until Brush brought out his arc lamp in 1877, followed a year later by his series arc-light dynamo. It is of historical interest to note that Cleveland was the first American city to employ arc lamps for street lighting.

Following closely upon the introduction of the arc lamp came Edison's incandescent lamp in 1879. About this time he also brought out his dynamo for incandescent lighting, 12 of these being installed in 1882 in the Pearl St. Station in New York—one of the first central stations in the country. These machines each had a capacity of 1200 incandescent lights (about 110 kw.) and occupied a floor space about one-ninth as great as the 30,000-kw. machine herewith shown, which is installed in the Waterside station of the New York Edison Co., the successor to the old Pearl St. station. They were horizontal, bipolar machines, each direct-connected to a simple engine mounted on the same base-plate, the whole unit weighing 61,550 lb. This is about 560 lb. per kw. as compared with 320 lb. in the 30,000-kw. unit.

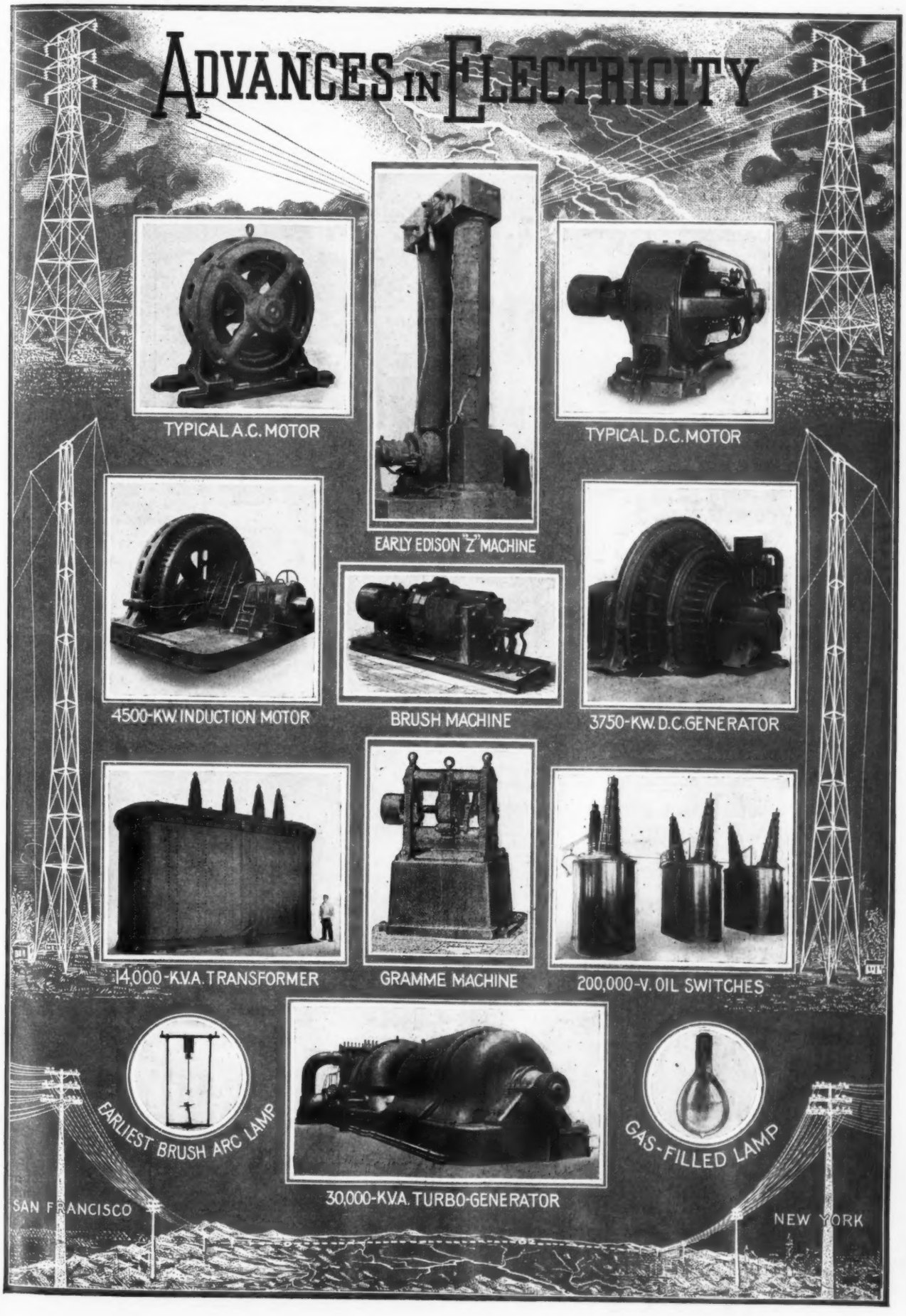
The first commercial electric railway was built by Sprague in 1887. Marconi brought out his wireless in 1895, and, with the perfection of the electric motor, electric drive came into general use in manufacturing establishments. Steady progress was made, accompanied by increased efficiency, and although the rate of increase in both efficiency and size of units is becoming less as might be expected and as was pointed out recently by Paul Lincoln in his presidential address before the American Institute of Electrical Engineers, the past 10 years has witnessed the greatest strides in the magnitude of electrical applications. During this period the maximum sizes of generators have increased about fivefold, transmission voltages have been nearly tripled, and the distances covered have increased proportionately; transatlantic wireless for commercial work has been established, and the transcontinental telephone is now in everyday use.

The increase in the size of units and transmission voltages has been brought about largely through the development of large central-station systems, by the consolidation and interconnection of smaller ones, and through the development of hydro-electric power, which usually must be transmitted over great distances to the electrical markets. Another factor which cannot be overlooked in this connection is the increase in motor load on the big stations, statistics from the last census showing that for central stations alone, during the period of 1902 to 1912, the number of motors served increased 330 per cent., with a corresponding increase in power of 843 per cent. This is exclusive of the increase in motor load in establishments which generate their own electricity. The same source shows an increase in central-station capacity from 1,845,048 hp. in 1902 to 7,528,548 hp. in 1912.

During the last few years illumination has become a distinct branch of electrical engineering, and marked progress has been made not only in better street and interior illumination but in the lamps themselves. A great stimulus to incandescent lighting was the introduction of the tungsten lamp, which more than doubled the efficiency over the so-called carbon filament type, and still further by the gas-filled lamp, which shows economies from 0.8 to 0.5 watt per candlepower, the latter figure applying only to the large sizes. These improvements in incandescent lighting naturally were accompanied by improvements in the arc lamp, and we now have the magnetite arc and flame arc lamps for street illumination, representing the highest efficiency lamps yet on the market. The honors seem to be shared by the gas-filled lamp and the luminous arc for street lighting.

In passing it may be of interest to note some of the largest pieces of electrical machinery which have been put out to date. The chart herewith does not represent in all cases the largest units, but rather shows the representative types.

The largest steam-turbine-driven alternator is that recently built by the General Electric Co. for the Philadelphia Electric Co. This is a three-phase 60-cycle 13,200-volt machine of the horizontal type running at 1200 r.p.m and weighs 1,200,000 lb. The Pacific Light & Power Co. possesses the waterwheel-driven generators of greatest capacity. They are rated at 17,500 kv.-a. and run at 375 r.p.m. The largest direct-current generators are of 5200-kw. capacity, and are to be found in the plant of the Southern Aluminum Co. Fourteen thousand kilovolt-amperes represents the capacity of the largest three-phase transformers which are of the shell type, 25-cycle, 6600—100,000 volts, and are in use on the Shawinigan Water


ADVANCES IN ELECTRICITY
TYPICAL A.C. MOTOR
EARLY EDISON "Z" MACHINE
TYPICAL D.C. MOTOR
4500-KW. INDUCTION MOTOR
BRUSH MACHINE
3750-KW. D.C. GENERATOR
14,000-K.V.A. TRANSFORMER
GRAMME MACHINE
200,000-V. OIL SWITCHES
EARLIEST BRUSH ARC LAMP
30,000-K.V.A. TURBO-GENERATOR
GAS-FILLED LAMP
SAN FRANCISCO
NEW YORK

& Power Co. system. The Westinghouse Electric & Mfg. Co. has built a number of 4500-kv.-a. (6000-hp.) induction motors for use in steel mills. They are 25-cycle three-phase machines. The largest synchronous condensers are those in use by the Southern California Edison Co. for power-factor correction on its high-tension transmission lines. These machines are rated at 6000-kv.-a. capacity, and operate at 16,500 volts. Twenty-five hundred kilowatts seems to be the limit at present for 60-cycle synchronous converters, and circuit-breakers have been built for 20,000-amp. maximum capacity.

The highest transmission voltages in operation in this country at present are 150,000 volts, on the system of the Pacific Light & Power Co., transmitting a distance of 241 miles on the Big Creek development. The Au Sable Electric Co. operates at 140,000 volts, and transmits a distance of 245 miles. This is closely approached by the system of the Southern Sierras Power Co., which transmits over 239 miles of transmission line at 140,000 volts.

While the United States is far ahead of Europe in the alternating-current transmission voltages applied, the reverse is true as regards transmission by direct current. The highest direct-current transmission is at 90,000 volts, from the Trollhättan Falls in Sweden. This is on the Thury System, operating 20 direct-current generators in series. Among the highest direct-current voltages in this country is that employed on the electrification of the Chicago, Milwaukee & St. Paul Ry. through Montana. This will ultimately cover a distance of 440 miles, and the trolley voltage will be 3000, with two 1500-volt direct-current motors in series.

Multiflex Atmospheric Exhaust Relief Valve

The Multiflex atmospheric exhaust relief valve has been designed to relieve a vacuum system of any pressure above the atmosphere. It is illustrated in Fig. 1 and is made by the C. H. Wheeler Mfg. Co., of Philadelphia, Penn. The valve consists of a casing in which there is a brass valve deck that is divided into a number of rectangular ports arranged in rows, each port being covered by a phosphor-bronze sheet valve, coiled at one end. The valves in each row are mounted on and controlled by a slotted bronze stem, to one end of which is keyed a bronze crank which has a common connecting rod that communicates with an external lever and locking device. This not only allows the valves to be secured in either an open or closed position, but the valve can be seated with any desired degree of tension because of the coiled spring. The angles of the ports and valve seats avoids abrupt turns and gives the steam a smooth passage through them.

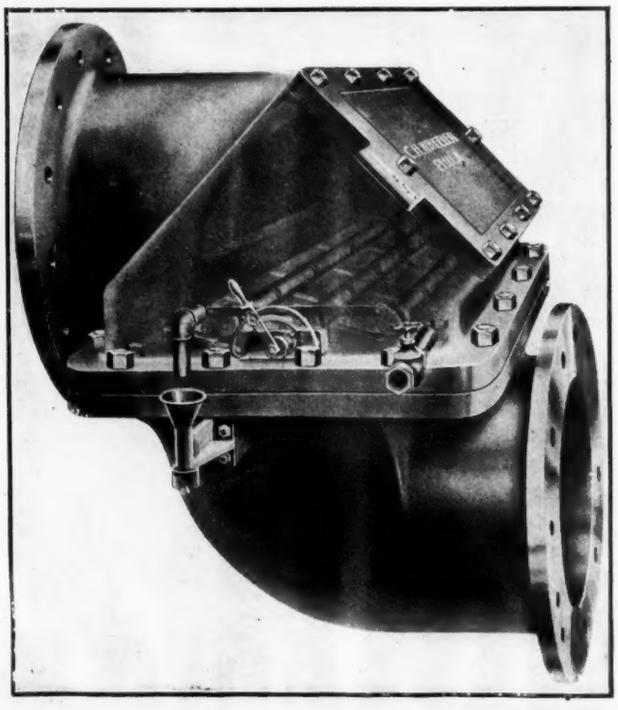


FIG. 1. PHANTOM VIEW OF THE MULTIFLEX RELIEF VALVE

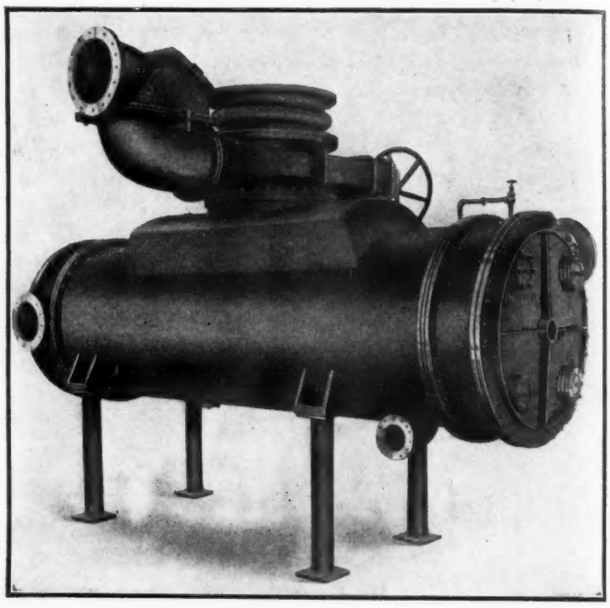


FIG. 2. APPLICATION OF MULTIFLEX RELIEF VALVE AND GATE VALVE TO A CONDENSER

Under normal operation the vacuum or unbalanced condition of the atmosphere holds the valves tightly on their seats, but to insure tightness for high-vacuum service a water seal is provided with a visible funnel overflow with a drain connection on the discharge side.

For small and medium-size units a special exhaust gate valve has been designed to be placed between the prime mover and the condenser. The disk is carried on rollers in all except the closed position, when a wedge forces the disk against the seat. A water-sealed stuffing box prevents air leakage past the stem. The application of the gate valve and multiflex valve to a condenser is shown in Fig. 2.

A Relief Valve in a Low-Pressure Line, near the reducing valve, is desirable as a safeguard and to call attention to an unusual pressure, especially if a small whistle is attached to the relief valve.

Testing Piston Rods—An electro-steel company has announced the results of a series of tests on piston rods made of the steel it manufactures. The steel showed a tensile strength of 123,775 lb. per sq.in. and an elastic limit of 82,600 lb., with an elongation of 24 per cent. in 2 in. and a reduction of area of 53 per cent. In a revolution testing machine 984,933 revolutions were required to break the test piece at a stress of 30,000 lb. per sq.in. This steel, which contains manganese, is produced in an electric furnace.

Visits of Inspector Brown--V

By J. E. Terman

SYNOPSIS—The Chief sends Brown to investigate the erratic action of a water column, which he later found was caused by the method of piping it to the boiler.

Brown left the office after his discussion of the subject of boiler draft with the Chief, to see what could be the matter with the water column on the distillery boiler that had been reported as acting queerly. He had made an inspection of the new No. 2 boiler at this plant just a week before, the boiler having been merely blocked up in position ready for the setting at the time, and he wondered if any changes had been made in connecting it up that would account for the present difficulty.

When he reached the distillery, he was met at the engine-room door by Kelley, the engineer. Kelley always had the appearance of being just ready to cry, and Brown had often wondered if this expression of grief was merely due to constant absorption of the distillery's output or if he really carried a sad heart under his shirt. Kelley seemed more alert this afternoon than usual, and when Brown asked him what was the matter, he said he didn't know, but that there was something wrong with the water column on No. 1 boiler. He said that the coal passer and general utility man had come to him shortly after the boiler had been started up and reported that the water in the column was jumping up and down, but that he had paid no particular attention to the complaint, for he had thought that the man had taken a few too many, to celebrate his return after a two days' shutdown. Kelley further stated that he had gone into the boiler room himself a short time before noon and had found the water in the boiler acting so strangely that he told his helper to pull the fire.

Brown asked how long the boiler had been acting in this way and was told only that morning, as it had been started up then after a two days' shutdown to permit the installation of a new smoke flue, made necessary by the placing of the new boiler in the plant.

"Well," said Brown, "I suppose you must have done something to No. 1 boiler when you put that smoke flue in."

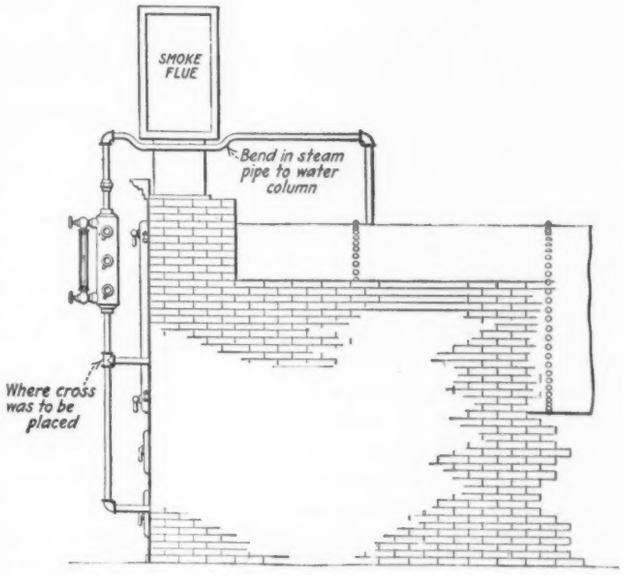
Kelley insisted that nothing had been disturbed but the smoke flue itself and said the only reason he had called up the insurance company was that after the fire had been drawn from under the boiler the water in the column still acted the same, and as he had never seen a foaming boiler that did not quiet down when it stopped steaming, he thought it was time to get outside advice.

"Well, Kelley," said Brown, "we will have to look after that boiler, for according to your description it certainly is acting queer."

They went to the boiler room and found that the boiler still had about sixty pounds' pressure and two gages of water in the glass, and to all appearances everything was O.K. Brown looked at Kelley, but Kelley merely said, "Wait a minute." Soon the water began to move up and down in the glass, slightly at first and then more rapidly, until it shot up out of sight; then in a second or two fell to its original position and came to rest.

"Well, that water column is some bad actor, Kelley," said Brown, "but I am sure that you are mistaken when you say that nothing has been done to it recently. Look where the connecting pipe to the steam space passes under the smoke flue; you have bent it down to get it out of the way, haven't you?"

"Yes," said Kelley, "that new smoke flue was higher than the old one and in order to keep it from coming too close to the ceiling, the bottom of the flue had to come closer to the top of the boiler than the old one did, and I had to get the steam connection to the water column out of the way. It had to be lowered only 2 in., and I thought the easiest way would be to bend it down. [The illustration shows what Kelley did to the piping.] The water column on that boiler never did sit plumb, and the bend that I put in the steam pipe just made it come right. I don't see how the bend has hurt the water column any."



HOW THE ENGINEER CONNECTED THE WATER COLUMN

"Well, Kelley," said Brown, "I don't want you to think that I am overbright on these matters or that I am passing you out snap judgment, but the reason that I know what is the trouble so promptly is that I experienced the same difficulty at another plant recently and it took me some time to figure out what caused the trouble there.

"You see that by bending that pipe you have made a trap in it to catch condensation, and when that trap is filled with water it acts the same as a valve would if placed in the connection and closed to shut off the steam from the boiler. When the supply of steam is closed off, the steam in the connections to the water column will condense, and this tends to remove the pressure from the surface of the water in the column, and it begins to rise. The removal of the pressure over the water in the column also tends to cause the pressure in the boiler to force the water from the trap in the pipe into the column and when a point is reached where the excess of pressure in

the boiler, over that in the column connections, is more than enough to support a column of water equal in height to the depth of the trap, the water is forced out of the trap, into the water column. When this action takes place a clear opening is provided temporarily through the steam pipe to the column and the indications of the column are normal until the condensation again begins to interfere with the free passage of steam to the top of the water in the column.

"The only thing that you need to do is to straighten the end of the steam pipe that you have bent, at the end near the water column and cut the nipple shorter in the vertical connection on top of the column. It is best to have the steam connection to a column arranged to drain toward the column, for this causes the condensation in it to run through the column back to the boiler, and in this way keeps it free from scale and deposit.

"There is an improvement that you might make, Kelley, while you are changing the water-column piping on this boiler, and that is to place a cross in place of the tee that you have below the column; and be sure that you put a brass plug in the unused outlet on this fitting, for I am expecting that you will remove it now and then to see if the pipes are clean. A brass plug, you know, will not corrode, and it is always easy to remove and there is no temptation to let it stay just because it sticks.

Kelley thanked Brown for the information given, and said that he would at once fix the water-column connections as directed. He also said that he would offer Brown a drink of the company's "best," but he knew that it would be useless to do so. He insisted, however, on Brown's smoking one of his Wheeling stogies, which were enough to kill any human but one inured to hardship by inspection work.

Measurement of Draft

By Prof. C. F. Hirshfeld*

SYNOPSIS—Draft defined, a study of the proper methods of measuring draft and the effect location of the gage has on its accuracy.

In previous articles† certain aspects of draft in stacks and boilers were discussed, but nothing was said with regard to the measurement of draft. It is the intention of this article to formulate certain definitions and, in their light, to study proper methods of measuring draft.

The under-pressure or draft at any point in confined, or partly confined, space may be described as the amount by which the absolute gas pressure at that point is lower than the pressure of the atmosphere outside that space at the same elevation.

It is first essential to note that this definition limits itself to one point, not to a section through an inclosure or to the interior of the inclosure in general. Thus if the draft in a horizontal flue is under consideration it can be spoken of, in exact terms, only with reference to a particular point in that flue and such a statement as "The draft in this flue is 1.2 in. of water" is without meaning in an exact sense. Thus if the flue happens to be, say, 6x6 ft. in section, measurements of the draft at points one foot apart vertically along lines spaced one foot apart horizontally will show remarkable variations in the same vertical section. Measurements made at one point will also show remarkable variations under apparently constant conditions.

There is nothing mysterious about all this but the causes of variation of pressure are so numerous that an analysis of the situation is sometimes rather tedious. In the first place, if the flow of gas along the flue were perfectly ordered, that is, if it occurred in the parallel flow lines so dear to the student of hydraulics, and if the flow were frictionless so that all particles in any vertical section were moving with the same velocity, and if the temperature were absolutely uniform over any vertical section, there would still be a variation of pressure from the top to the bottom of the flue. Assuming any pressure within the flue at the top the pressure would have to increase toward the bottom because of the weight of material above just as the pressure of the atmosphere increases as one descends a mountain. Putting this variation of pressure within the flue in terms of draft makes the phenomenon look more complicated than it really is. Assuming a certain difference of pressure between the gas just inside the top of the flue and the air outside at the same elevation it is an easy matter to predict the way in which that pressure difference will vary, over the vertical elevation of the flue. Were the pressure inside the flue to vary with depth in exactly the same way as the pressure outside, the pressure difference would remain constant, that is, would be the same at all heights. But, since the density of the gas within the flue is much lower than the density of the air outside, the weight of a given depth of flue gas must be less than that of a given depth of air and, therefore, the increase of pressure with increase of depth inside the flue must be less than the increase of pressure with a corresponding increase of depth outside the flue. It follows, that the difference between internal and external pressures must be greater at the bottom of the flue than at the top, which is equivalent to saying that the draft is greatest at the bottom and least at the top. The variation of draft from top to bottom would, of course, be small with such dimensions as were assumed above.

Superimposed upon this effect there are many others, the more important of which will be briefly summarized. First, the gases discharged from the average boiler are not uniform in composition or temperature over the area of the discharge nozzle, and they therefore pass into the flues as streams with different characteristics. Second, the loss of heat from the bottom and lower parts of the sides of a flue is different from the loss of heat from the upper part of the flue. This causes an unequal drop of temperature over the height of any section. Third, flow of gas is not frictionless so that the gas in the center of the flue moves faster than that near the walls. Fourth, bends and in-

*Chief of research department of the Edison Illuminating Co., Detroit, Mich.

†"Power," May 18 and Aug. 10, 1915.

equalities always exist in the walls of the flue. The net results of all of these conditions is a billowy, agitated flow with local but shifting areas of low pressure and similar local but shifting areas of high pressure.

In general, if readings be taken over long enough periods to cancel out the effects of such shifting areas, and, if they be taken in a straight run of flue, free from large obstructions and irregularities, the variations due to increase of density with depth will become evident. Such readings taken at any point and averaged for long periods of time may be truthfully spoken of as the average pressure (or draft) at that particular point and a grand average of such average readings at points uniformly distributed over any vertical or horizontal section may be

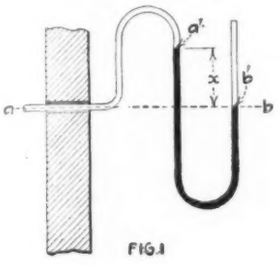


FIG.1

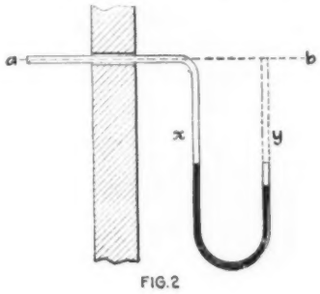


FIG.2

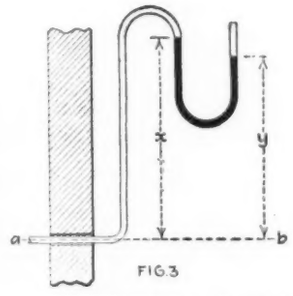


FIG.3

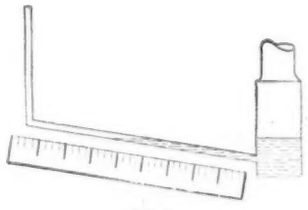


FIG.4

SHOWING POSITION OF DRAFT GAGES

truthfully spoken of as the average pressure (or draft) at that particular section. It is seldom, indeed, that readings of draft are taken at such a point and in such a way that they really represent such a value.

It is now necessary to consider the method of obtaining draft readings. These are usually obtained by means of a U-gage or some development of such a gage, filled with water or oil. The simplest possible case is shown in Fig. 1 in which the gage is located just outside the wall of the boiler or flue and at such a height that the top of the depressed leg is on a level with a point at which the draft or under-pressure is being measured. If it be assumed for the time being that the tube projecting through the wall is of such a kind as to give correct readings unaffected by velocity, eddies and such, it is obvious that the elevation of liquid, x, is a true measure of the difference between the pressures at a' and b' and therefore at a and b.

A case more nearly like that ordinarily met with is shown in Fig. 2. The gage is located at an elevation much lower than the point for which the value of the draft is desired. Remembering that the draft is the difference between the pressures at a and b it is evident from the figure that if the gas in the column x had the same density as that in the imaginary column y the reading of the gage would be correct and correspond exactly to that obtained with the arrangement in Fig. 1. Assuming the column x to consist of air, it must have a slightly lower density than does the column y if the two are at the same temperature, for the very simple reason that if the pressure at a is lower than the pressure at b, the column x exists under a lower pressure than does the column y. If the temperature of the column x is higher than that of the column y, the density of the gas in column x will be still further decreased.

If difficulty is experienced in recognizing the truth of these statements the following argument may be of assistance. Assume a gage located as in Fig. 1 and then imagine it to be gradually moved downward until it occupies a position like that indicated in Fig. 2. As it is moved downward the pressure on the liquid in each leg is increased by the weight of the gas between the plane ab and the new positions assumed by the liquid surfaces. If the weight of the gas column x always remains equal to that of the column y the reading of the gage will not be changed as it is moved downward. If, however, the density of gas in column x is less than that in column y the liquid in the left-hand leg of the gage must continue to rise as long as the gage is moved downward.

It is obvious that, when measuring under-pressure or draft at a with a gage located as in Fig. 2, the effect of low-density gas in the column x must be too high a reading of the left-hand leg, indicating greater under-pressure or draft than really exists at a. When measuring over-pressure at a, low-density gas in the column x would again cause the liquid in the left-hand leg of the gage to stand too high, but this would mean that the gage indicated a lower over-pressure than really existed at a. Both of these results would be just reversed if the density of gas in x were greater than that in y.

In any actual case of draft measurement the material in the column x may be anything from pure air to pure flue gas. As flue gas is practically air to which carbon has been added in such a way as not to change the air volume at any given temperature, flue gas must be more dense than air at corresponding temperature and pressure conditions. With flue gas in the column x there is, therefore, a tendency to balance the tendency of a gage in the position shown in Fig. 2 to read too high a draft.

The arrangement shown in Fig. 3 is obviously just the reverse of that shown in Fig. 2, and it can be analyzed readily by the method just used. Thus, assume the gage moved upward from the position shown in Fig. 1 to that shown in Fig. 3. As it rises the pressures upon the liquid surfaces decrease. If the density of gas in x is less than that in y the decrease of pressure on the liquid in the left-hand leg will be less rapid than that on the right-hand leg and the liquid in the left-hand leg will therefore be depressed. For under-pressure or draft at a, the gage would give too low a deflection in position 3 with density in x less than density in y. With density in x greater than in y the exact opposite would be true.

From what has preceded it is obvious that readings of slight over- or under-pressures obtained with a U-gage located at any level other than that at which the pressure difference is to be determined may be open to question unless elaborate corrections are made. Unfortunately these corrections are difficult to make, both because they involve the use of rather complicated formulas and because the determination of the temperatures, pressures and densities which must be substituted in the formulas is generally a difficult matter. Under such circumstances

it is advisable to investigate the magnitude of the errors introduced by neglecting such corrections. Actual calculations show that for ordinary conditions with small boilers and flues, involving small differences of elevation, the errors are small indeed and may be safely neglected. For large boiler installations where differences of the elevation of from 30 to 100 ft. must be considered, the errors resulting from gage location may amount to values of such magnitude as to seriously affect results obtained by the use of modern forms of differential gases.

These errors should not be neglected under such conditions when making tests of an accurate character. They may be eliminated from the results by calculation or by the location of the gages at the points at which the pressure differences are to be determined. The latter procedure is in general the simpler and the more exact. One example of a particularly bad arrangement once actually used may serve to emphasize the necessity of observing proper precautions in making observations of this character.

In this case the draft at a certain point in a flue was to be observed and this point was located 30 ft. above the level at which the gage was located. The tube leading from the flue to the gage was carried along the flue and down some metal work in the side of a boiler and then horizontally to the gage. The gage happened to be located immediately below a long window in an outside wall and the outdoor temperature happened to be low. As a result of this arrangement the gas in the column which has been designated by x had a temperature of about 125 deg. F., while the column which has been designated by y had a temperature of about 50 deg. F. Neglecting all variations but that due to temperature this gage must have indicated a draft too high by more than 0.05 in. of water, an error which should not be neglected when using a differential gage reading to hundredths of an inch of water.

A form of "differential" or multiplying draft gage which is now extensively used is shown diagrammatically in Fig. 4. The theory of this gage has been described so often in recent publications that it seems unnecessary to repeat it here. The gage is usually so constructed that the scale reads in inches and fractions of an inch of water although some liquid other than water is actually used in the instrument. Assuming that the instrument is so perfectly constructed that it is capable of giving correct readings, an assumption not always warranted by fact, and assuming further that the instrument is so located and connected as to eliminate all sources of error discussed above, it is possible and even probable that the readings obtained will still be inaccurate. It must be remembered that the gage simply reads the weight of a column of liquid which is required to balance a certain small pressure difference. The density of all liquids changes with temperature, in general decreasing as the temperature increases. But the lower the density of a liquid, the higher the column of that liquid which is required to balance a given difference of pressure. If the readings of such a gage as that shown in Fig. 4 are to be used to the degree of accuracy which the scale graduations would imply, i.e., hundredths of an inch of water, the temperature of the liquid should always be read and the indications of the gage corrected accordingly. This is particularly the case when the gage is fastened to the wall of a flue carrying hot gases or to the wall of a boiler.

The corrections to be applied are easily determined by measuring the density of the liquid at different temperatures by means of a hydrometer and then drawing a curve between density and temperature. Trials with the liquid in the gage at different temperatures in the neighborhood of 60 deg. may then be used to determine the temperature at which the scale graduations are correct. The density of the liquid at this temperature can then be read from the curve and all readings subsequently taken at different temperatures can be corrected to this standard temperature by simple proportion, remembering that for a liquid whose density decreases with rise of temperature the gage reading is too high for temperatures above the standard and too low for temperatures below the standard.

During the past few years the use of differential draft gages graduated to hundredths of an inch of water has become quite common. It must not be assumed that because the gage is graduated to read such small differences it is necessarily accurate to the degree which this would imply. Some of these gages when accurately tested have proved to be inaccurate to the extent of several hundredths of an inch at certain parts of the scale and they should therefore be calibrated before being used for accurate testing purposes.

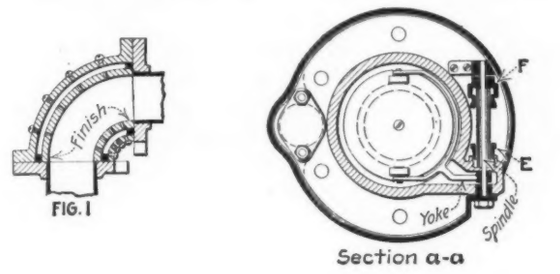
Levin Flow Meter and Metering Flow Bend

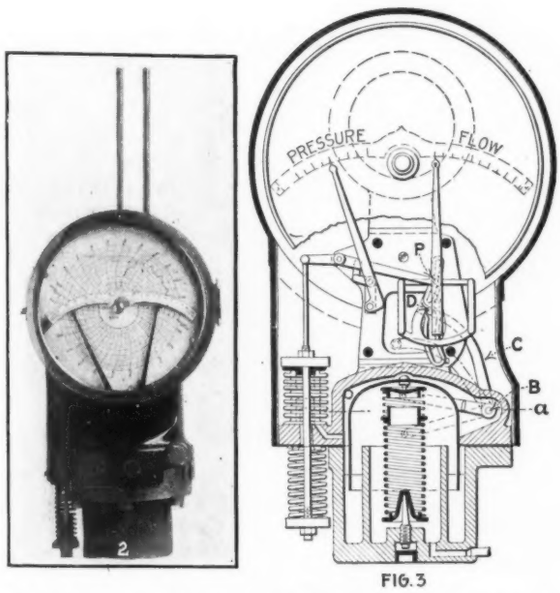
An interesting instrument for measuring the flow of compressible fluids, air, steam or gases in general has recently been designed by A. M. Levin, 925 Monadnock Block, Chicago. The intention is to operate the instrument in conjunction with the Levin flow bend described in a paper read by the inventor before the American Society of Mechanical Engineers, June, 1914. The flow bend and the indicating and recording instrument are shown in the accompanying illustrations. The former consists simply of a pipe bend or elbow properly calibrated and provided through its outer and inner curved walls with suitable pressure ports. Instead of determining the velocity of the fluid or gas from its inertia pressure, as in the pitot tube and venturi meter, the flow bend utilizes as a gage the centrifugal force exerted in deflecting the course of the medium through a definite path determined by the radius of curvature of the bend. As the centrifugal action depends on the true angular velocity of the fluid, eddies and whirls only nominally affect the pressure registered at the ports. This is particularly true when a number of pressure ports distributed along the sweep of the bend are employed. The pressure difference between the inner and the outer sets of ports will, for equal velocity, ordinarily be twice the pressure difference indicated by the pitot tube. Accordingly, an indicating or recording instrument attached to the flow bend should act more positively and be more sensitive to variations in velocity. In almost every pressure line there will generally be found some elbow that can be removed for a standard flow-measuring bend fitting its place; but if it should develop that there is no place for such a bend, the metering instrument can be attached to a venturi meter or pitot tube.

In all fluid velocity-measuring apparatus on which the operation of flow meters depends, the velocity of flow is gaged by certain pressure differences established as a consequence of the energy of the passing fluid. The

higher the velocity of the fluid, the greater its energy, and consequently the greater the manifested pressure difference becomes. This pressure difference, which can conveniently be expressed as a head in inches of water, does not stand in a direct ratio to the velocity of flow, but in such a ratio that the velocity of flow squared is proportional to the number of inches of water indicated. The function of the flow meter becomes, accordingly, to measure correctly the pressure head and to indicate and record this pressure head, transposed into volume of flow, or, as usual, into weight of flow per time element.

From Fig. 3, which is a sectional view of the meter, it will be evident that the difference in pressure is measured by a spring under a bell sealed by mercury.





FIGS. 1, 2 AND 3. DETAILS OF THE LEVIN FLOW METER
Fig. 1—Metering bend. Fig. 2—Flow meter. Fig. 3—Section through the meter

The pressure at the outer wall of the metering flow bend is admitted between the casing and the bell, pushing the latter downward and compressing the spring. The pressure at the inner wall of the bend is transmitted to the interior of the bell and consequently pushes the latter upward against the exterior pressure. The difference in the two pressures, then, is measured by the spring. In case a pitot tube is used instead of a metering bend, the total pressure in the pipe line would be admitted exterior to the bell and the static pressure to the interior, so that the velocity head would be measured by the spring.

By means of a yoke *a*, Fig. 3, attached to the bell, a spindle *B* and lever *C*, the movement of the bell or spring is transmitted to the pin *D*. This pin operates in a parabolic link designed to obviate the square-root sign in the velocity formula, so that the pointer will indicate directly the pounds of steam flowing in the pipe. Where the pressure varies 10 to 15 per cent. or more, as it might easily do in a paper mill, the meter is provided with a compensating device consisting of a corrugated brass tube operating against a spring. The tube has a movement of approximately 3/8 in. As the pressure increases above normal the tube tends to elongate, or if the pressure decreases the spring will tend to compress the tube. Pressure is admitted within the corrugated tube, and if the spring has been properly adjusted there will be no movement when the pressure is normal. With variations of pressure, however, there will be a movement either up or down, which is transmitted by the double lever shown in Fig. 3 to the slotted link attached to the tilter controlling the pointer indicating the flow. When there is no flow of steam and the pointer is vertical, the lever pin *P* merely moves up and down in the slot and does not affect the reading. When steam is flowing and the inclined pointer indicates a reading, a correction will be made for any variation in density by a movement of the pointer parallel with its inclined position. In the ordinary plant pressure varies usually only a small percentage, so that the compensator will not be needed.

A second pointer linked to the compensating lever indicates the pressure in the pipe line, and to this same pointer a recording pen marking on a revolving 24-hr. chart may be attached if desired. A recording pen is always attached to the pointer indicating the flow of steam, and when the two recording pens are used they may record on the same chart, but in different color inks. The scales of the flow and pressure indicators are both secured to the glass front frame, so that in replacing a chart both may be swung out of the way.

Facilities are provided for attaching a U-tube manometer by which the reading of the instrument can be compared to make sure that it is in good condition and its adjustment undisturbed. The clock movement and all moving parts are inclosed in a black-rubber, enameled, cast-iron or aluminum dust-proof casing, which in conjunction with a polished front glass frame in brass or nickel gives the instrument a finished appearance.

From Fig. 3 it will be evident that a light spring mounted between flanged washers is used to make the lower readings more sensitive. When these washers come together the heavy spring does the weighing. In this way accurate readings can be obtained at all points of the scale, especially as friction has been practically eliminated. There is no packing box impeding the free motion of spindle *B*. Special precautions are taken to guard against friction by using a flexible tube between the stuffing boxes *E* and *F* shown in the upper view of Fig. 3. A ferrule inside of this tube prevents the stuffing boxes from clamping down on the spindle.

It is worth noting that every instrument has the same calibration constant—that is, every instrument can be made to indicate the same maximum flow over a standard scale by a slight adjustment of the compensator. When the corrugated tube or pressure indicator is omitted, a rod of proper length is attached to the compensating device so that its position can be adjusted by hand. In this way identically the same charts can be used on any meter, and the divisions of the charts will be uniform. In other words, on any chart an equal number of pounds of steam will be represented by equal divisions throughout the motion of the indicating pointer or recorder pen.

The Panama-Pacific Exposition—VI

By F. R. Low

SYNOPSIS—Gasoline engines are used in larger sizes and for more serious purposes on the West than on the East coast. Descriptions of the larger of those exhibited.

Carburetor-Type Engine

The carburetor type of engine burning gasoline, distillates, kerosene, tops (as the lighter products drawn off from the surface of tanks of settled crude are called), anything in fact between 40 and 80 deg. Bé., is numerously represented. Such engines are in extensive use on this coast for serious marine purposes, the majority of the tugboats, barges, etc., up to 150 ft. in length, using them. A three-cylinder marine of 100 hp., built by the Union Gas Engine Co., of San Francisco, with cylinders, valve cages, etc., sectioned in order to show their operation, is run by a motor in the exhibit of the Standard Oil Co., Fig. 29. It has a 12-in. bore, 15-in. stroke, and is claimed to develop 120 hp. at 280 r.p.m., for which it would require a mean effective pressure of 74.2 lb. at 90 per cent. mechanical efficiency. The cylinders are of the T-head type, as shown in Fig. 30, a removable head and valve covers being provided so that it is unnecessary to lift a heavy head when removing a valve. All of these engines above 80 hp. are fitted with open crossheads, cylinders and pistons, allowing direct and visible lubrication of the piston-pin from the force-feed oiler and easy adjustment of the piston-pin brasses.

A special feature of this engine is a universal inlet manifold, by which it is possible to distribute to all the cylinders from a single carburetor, even when using kerosene and the lower grades of distillate. The fuel-charged air from the carburetor is carried through a spreading chamber jacketed with exhaust gases, preventing precipitation and insuring a uniform mixture to all cylinders at all loads and speeds. A cock *A*, Fig. 30, at the connection of the manifold with each cylinder allows that cylinder to be shut off while the others are running. These cocks are not, however, upon the engine shown in Fig. 29. The Union Gas Engine Co. has a 600-hp. engine 43 ft. in length and weighing 120,000 lb. in the ferry boat "Ramon," which illustrates what I have said about the use of gasoline engines for serious marine work. It claims to have been the first to commercially apply a gasoline engine to marine propulsion and exhibits alongside the sectioned engine its first gasoline engine, built in 1884. Daimler exhibited in Paris in 1889 a light high-speed gasoline engine which was applied to a launch, but it was of the hot-tube ignition tube, while the Unión engine had electric ignition. It appears in the foreground of Fig. 29, and a photograph of it is reproduced on a larger scale in Fig. 37.

The largest stationary example of the type is a 200-hp. four-cylinder vertical by the Doak Gas Engine Co., of San Francisco, Figs. 31 and 38. The cylinders are 11¾-in. bore, 15-in. stroke, and it needs to run at 280 r.p.m. in order to develop its rated 200 hp., requiring a mean ef-

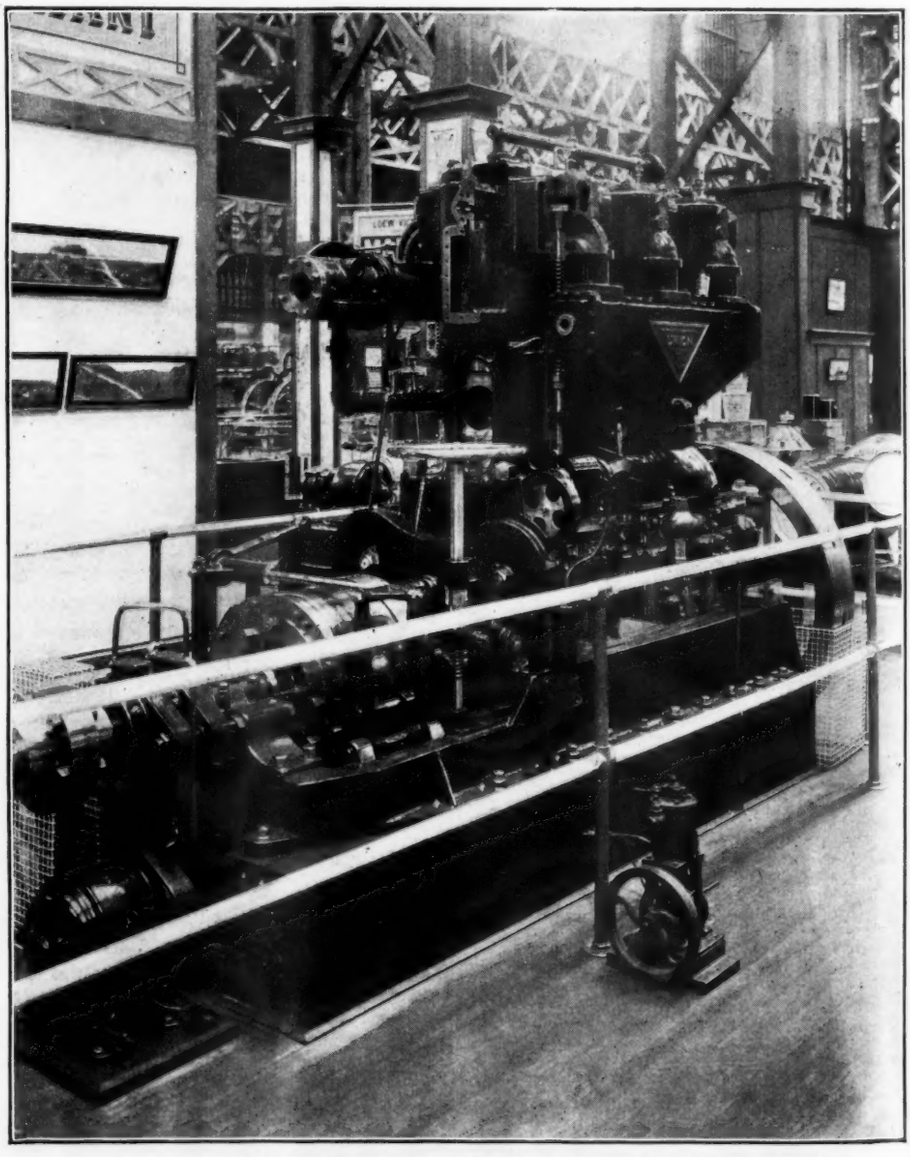


FIG. 29. UNION GASOLINE ENGINE IN STANDARD OIL CO.'S EXHIBIT

fective pressure of 96.6 at 90 per cent. mechanical efficiency. One carburetor is used for the four cylinders, delivering into the center of the manifold *A* which distributes the mixture to two cylinders at each end, the discharge being baffled to induce uniformity of distribution. The air to the carburetor is drawn from a jacket about the exhaust pipe, and its temperature is controlled by a slide which permits more or less cool air to enter at the top of the connecting pipe *B*. The admission valve is horizontal, and the exhaust vertical and central in the cylinder head. The governing is by throttling the mixture. An air-starting valve is provided at *C* and a relief cock at *D* for the compression. The connections for the forced-feed lubrication are shown at *EE*. The stem of the exhaust valve gets some benefit from the water jacket of the head, and the valve itself is cooled by the incoming charge. No cage is used for the exhaust valve, so as not to interfere with the cooling effect, but the inlet valve is in an easily removable cage. Both valves are, however, arranged to permit removal for inspection or regrinding without disturbing the manifold. The carburetor is carried high so that no condensed fuel can collect in the manifold.

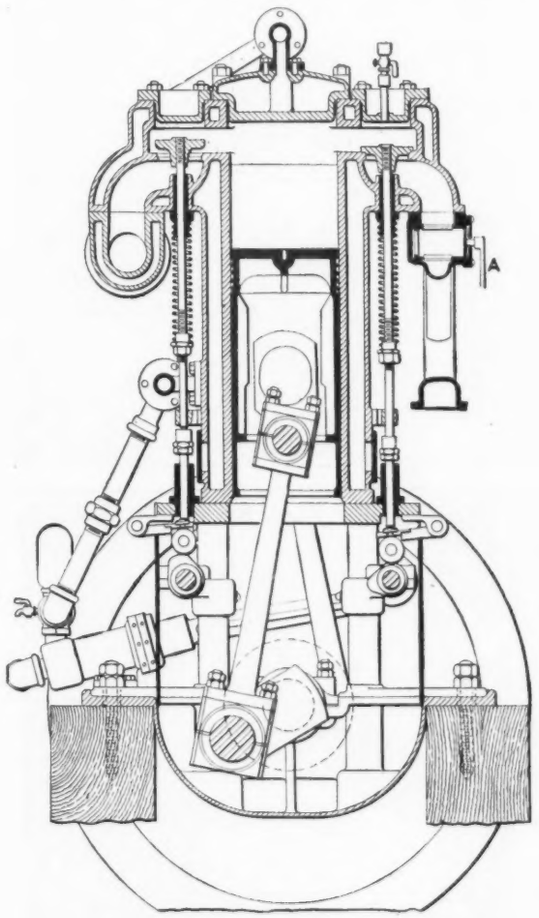


FIG. 30. THE UNION MARINE ENGINE

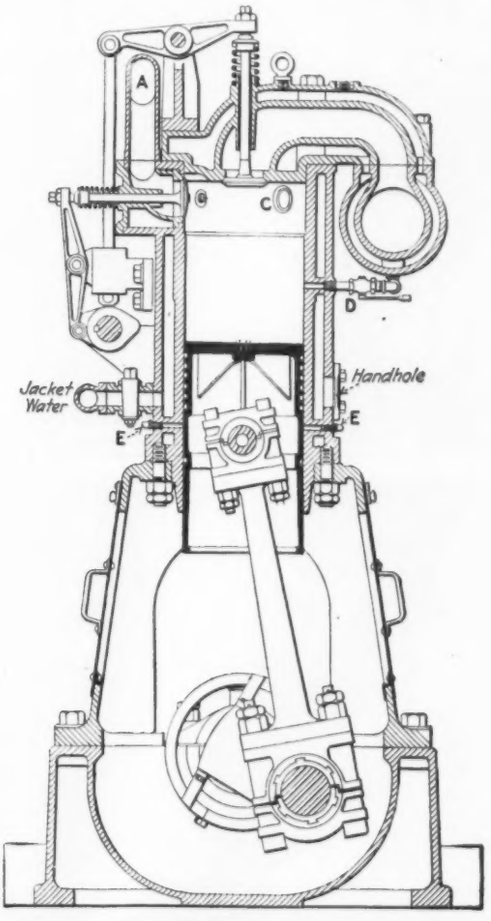


FIG. 31. THE DOAK STATIONARY ENGINE

The exhibit of the Western Gas Engine Co. is shown in Fig. 32, and Fig. 36 shows a section through the cylinder and valves. The valves are opposed vertically in a side chest, the fuel delivered into the space *B* enters through the control valve *E* and is picked up by the air entering at *A*. When the condition makes its use in the mixture desirable, water is admitted to the chamber *C* through the control valve *F* and is sprayed into the incoming air by the nozzle *D*. These engines are all horizontal, the largest exhibited being a 60-hp., running idle. There are 20-hp. stationary and portable engines, a 30-hp. mining hoist, a 30-hp. oil-field engine with a reversible clutch, and a 35-hp. operating an electric fan and pumping water for a fountain.

One of the most largely used engines hereabout is that of the Standard Gas Engine Co., of San Francisco. Its exhibit, Fig. 33, is one of the most striking and contains the largest number of engines of any in Machinery Hall. The largest example is a 175-hp. four-cylinder 11¾x15-in. 280 r.p.m. These engines are used in the fleet of excursion boats connected with the Exposition.

The Imperial Gas Engine Co., of San Francisco, exhibits, Fig. 34, a three-cylinder 75-hp., a four-cylinder 50-hp., a two-cylinder 16-hp., and a single-cylinder 6-hp. A distributing manifold with hot air from the crank case and independent shut-off cocks are used. The two smaller engines are driven slowly by a motor.

It is impossible to describe, illustrate, or even to enumerate all of the exhibits in this line, and most of them have little application to large power-plant work. A word should be said, however, of the exhibit of the International Harvester Co., which, besides a large line of agricultural machinery, builds many engines for stationary purposes. Its exhibit, Fig. 35, in the Agricultural Building contains 37 engines of different types, 13 of these the so-called Moguls made at the Chicago works and 24 Titans made at Milwaukee. A sectioned engine of each type is shown, one being turned around by a motor, and most of the other

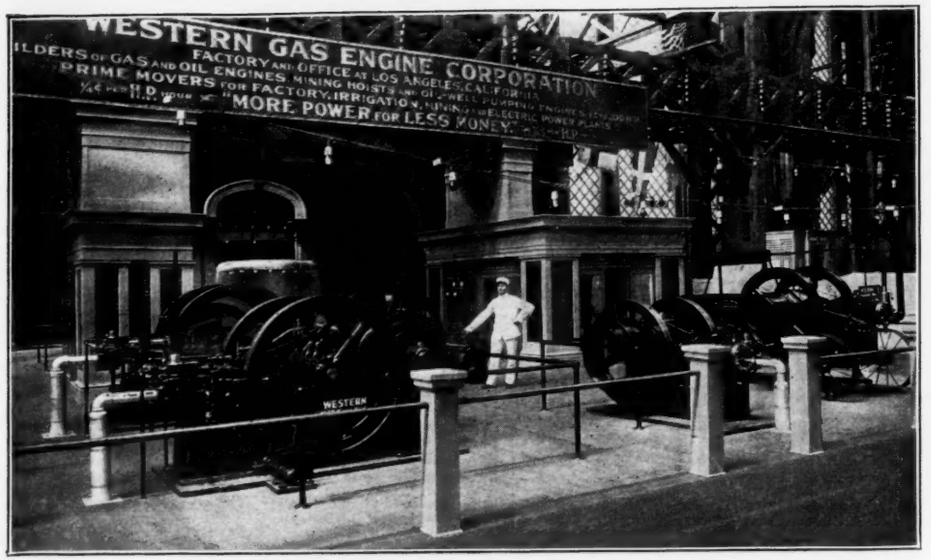

WESTERN GAS ENGINE CORPORATION
FACTORY AND OFFICE AT LOS ANGELES, CALIFORNIA
BUILDERS OF GAS AND OIL ENGINES, MINING HOISTS AND OIL WELL PUMPING ENGINES
PRIME MOVERS FOR FACTORY, IRRIGATION, MINING AND ELECTRIC POWER PLANTS
"MORE POWER FOR LESS MONEY"
WESTERN

FIG. 32—WESTERN GAS ENGINE CORPORATION

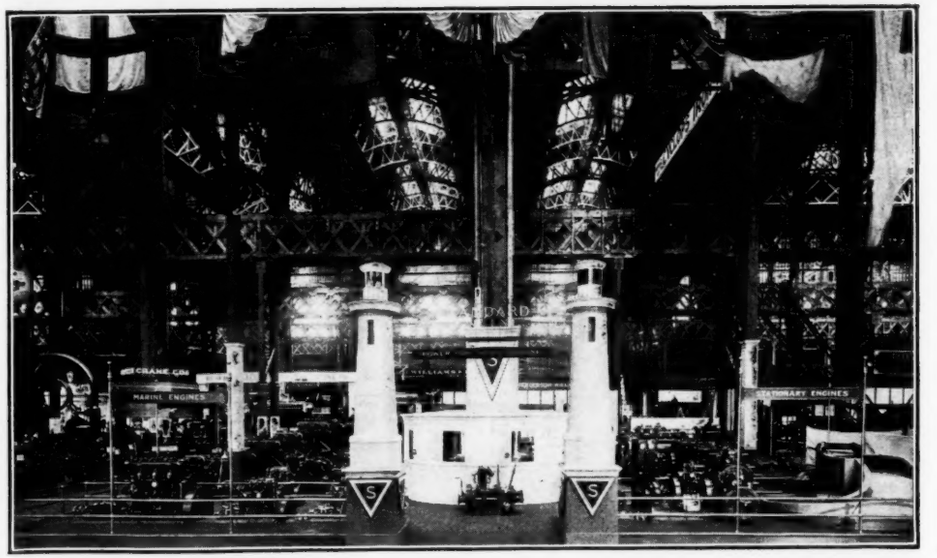


FIG. 33—STANDARD GAS ENGINE CO.

FIG. 34—IMPERIAL GAS ENGINE CO.

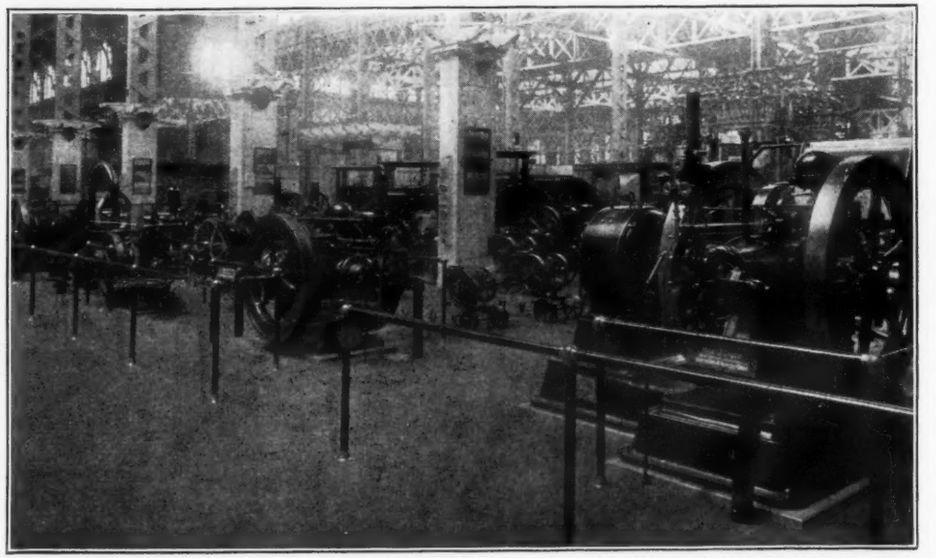


FIG. 35—INTERNATIONAL HARVESTER CO.

FIGS. 32 TO 35. SOME OF THE EXHIBITS OF ENGINES OF THE GASOLINE OR CARBURETOR TYPE AT THE PANAMA-PACIFIC EXPOSITION

engines are run either by motors or by compressed air. The separate parts of the engines are also exhibited upon the tables, and there is a comprehensive display of magnetos and oilers. The engines are set upon stationary foundations and mounted upon skids and in various ways

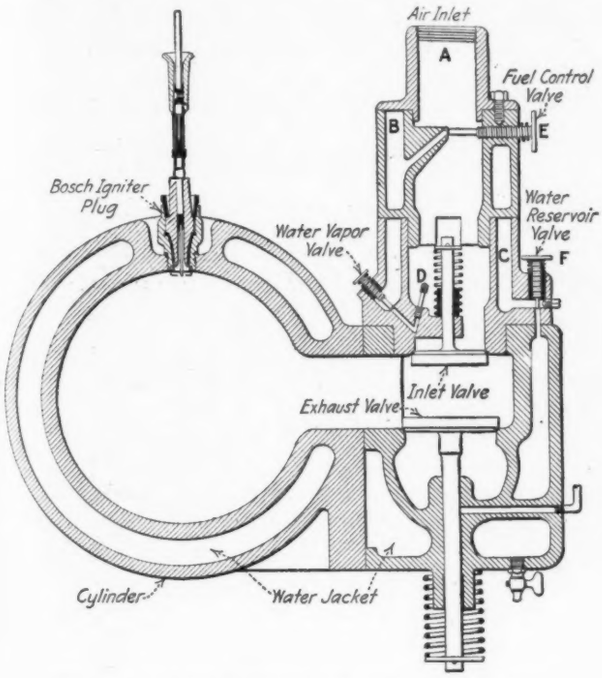
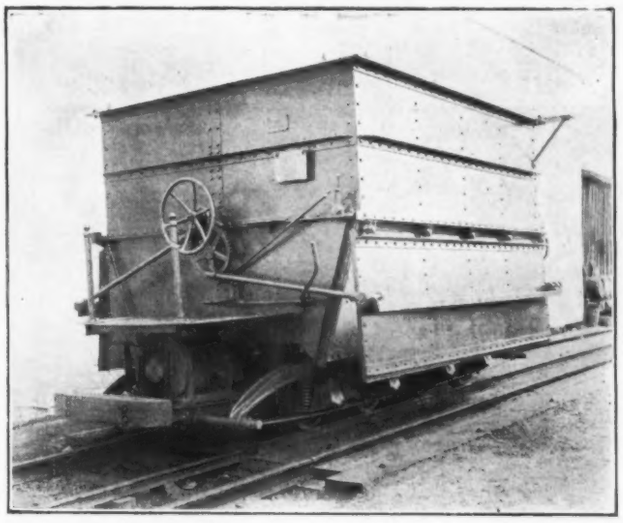


FIG. 36. VALVE SYSTEM OF WESTERN ENGINE

for farm purposes, the largest examples in the stationary line being the 50 hp. Mogul with two opposed 10x12-in. cylinders running at 350 r.p.m., and a Titan of the same capacity with twin 9x14-in. cylinders running at 335 r.p.m. The preponderance of the internal-combustion engine is not indicative of the general relative standing of the type, but is due to the extensive use of such engines in this oil-producing district and the comparative ease with which they are exhibited.

Coal Cars for Canal

The illustration shows one of the 88 W bottom cars for the Cristobal coaling station, Panama Canal. One axle on both trucks of the car is driven through an automobile type of worm gear by a three-phase 25-cycle 440-volt constant-speed motor. As shown, the motor castings are ribbed to increase the radiating surface. Each car



COAL CAR USED AT PANAMA CANAL

is of 10 tons capacity, and will run at 200 ft. per min. on 30-sec. headway, and therefore one track loop will handle a maximum of 1000 tons per hr. Two track loops at Cristobal will handle an average of 2000 tons per hr.

The 34 cars for the Balboa coaling station will be of similar design, but the bodies will be built to dump one way only, through a single door. Trackmen load, start, dump and stop the cars, but no attendants are required when the cars are in motion. These cars were designed by the Bergen Point Iron Works, Bayonne, N. J. A full description of these coaling plants was given in *Power* of June 24.

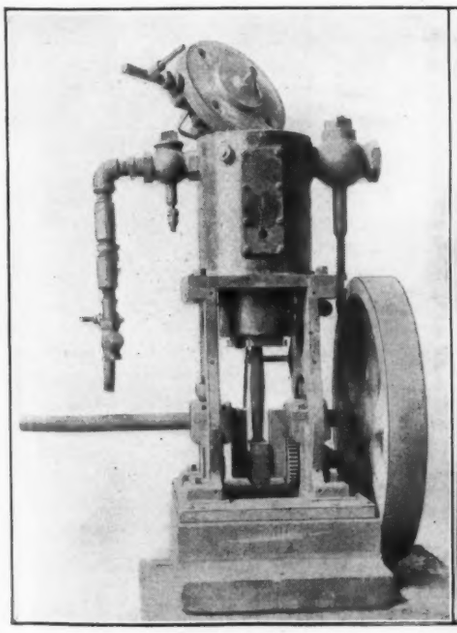


FIG. 37. A PIONEER

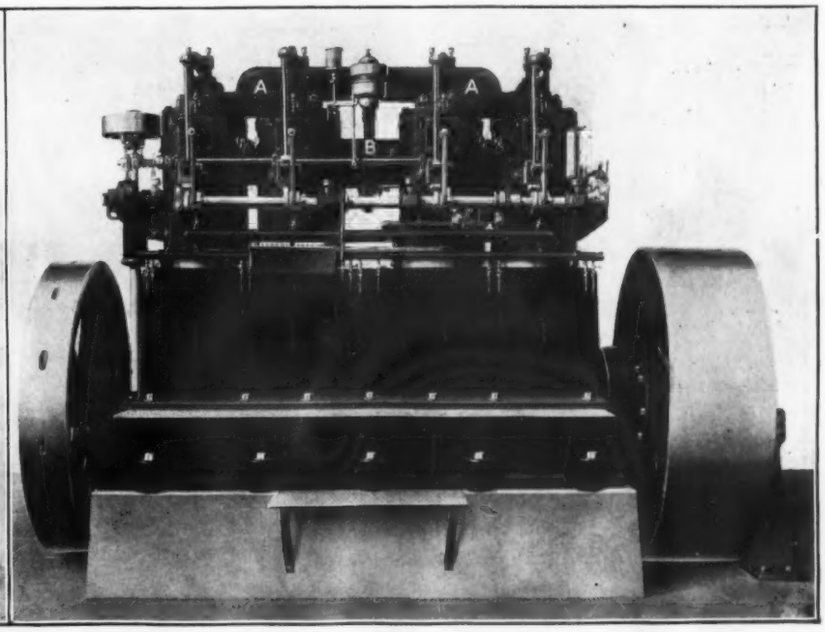


FIG. 38. DOAK 200-HP. STATIONARY GASOLINE ENGINE

FIGS. 32 TO 35. SOME OF THE EXHIBITS OF ENGINES OF THE GASOLINE OR CARBURETOR TYPE

Multiple-Unit Boiler Control

By Ernest F. Fisher*

SYNOPSIS—By an arrangement of mercury U-tube indicators, one on each boiler, a green light is made to burn when the boiler is doing its share of steam making, and a red light shows when it is not. Electric-pneumatic valves operated by these indicators may be used to vary draft and stoker feed.

The advances made in the building of highly efficient prime movers using steam have not been equaled by improvements in generating steam at the highest efficiency and economy. The results fall short of those desired. An electric generating machine is highly efficiently controlled. In the plant each generator bears its proportionate share of the load. This cannot be said of the most modern of steam generating plants (the two are analogous) where all depends on the proper functioning of the various processes of combustion, evaporation, etc., under all conditions.

Attempts are made to obtain proper functioning through the aid of apparatus responsive to variations in pressure of the steam. Another method is to control the functioning by apparatus responsive to variations in output of each boiler regardless of what the demand may be upon the whole battery. Neither method gives the desired results.

The problem is so to function the processes of combustion, evaporation, etc., that each boiler bears at all times its full share of the total load upon the whole battery, regardless of how much the total power demand may fluctuate. This means maximum economy and efficiency.

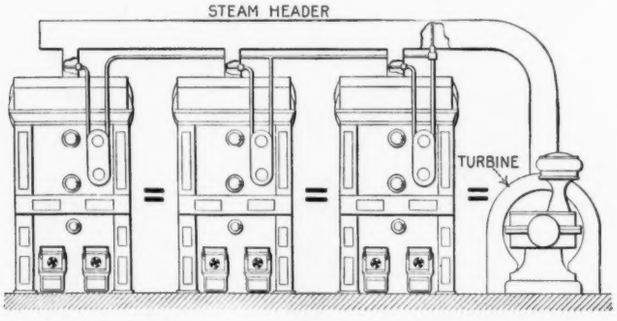


FIG. 1. BOILERS EQUIPPED WITH MULTI-UNIT CONTROL SYSTEM

Task-setting for firemen is a step in the right direction, but task-setting for boilers is a direct application of a means to an end, for we are most directly concerned with the amount of energy the boilers are delivering and not with the fireman.

If it were possible to substitute for a battery of boilers one of huge dimensions having a capacity of the whole battery, troubles in the boiler plant would greatly diminish, as all operations would be centralized in one unit and the attainment of the highest efficiency with the least cost would be assured. Manifestly such a plant would be impractical; so the next best thing is to get as many small units as are necessary, but see to it that all work together as one. This is an ideal condition and possible of attainment with the multiple-unit boiler control described herewith.

This set of ideal conditions may be expressed in the form of simple equations: $\frac{V}{V_1}$ = Constant; $\frac{V}{V_2}$ = Constant; $\frac{V}{V_3}$ = Constant; $\frac{V}{V_4}$ = Constant; V being the velocity of the steam in the header line due to the power demand on the whole battery and V_1, V_2, V_3 and V_4

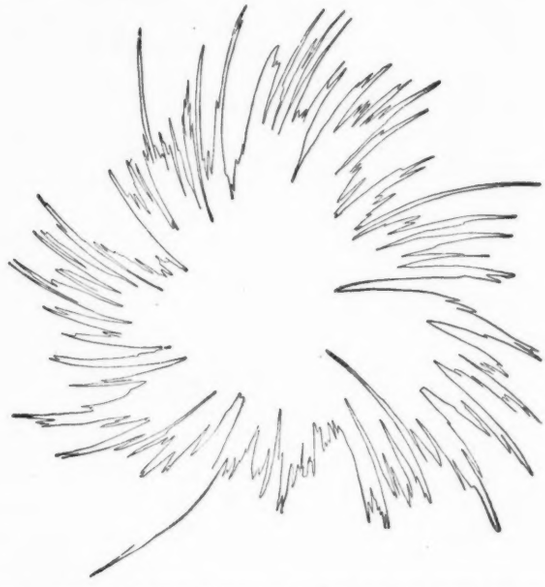


FIG. 2. STEAM LINE FROM CHART FROM STEAM FLOW METER. NOTE HOW FLOW FLUCTUATES

the velocities in the several leader lines—pipes from the boilers to the header.

The pressures due to the velocity heads in these two sets of steam lines meet in opposition in the indicators shown in Fig. 1. The best values for $\frac{V}{V_1}$, $\frac{V}{V_2}$, $\frac{V}{V_3}$, $\frac{V}{V_4}$ are determined and the indicators set for that value. When that value is exceeded or not attained, the indicator immediately shows the condition, and balancing of the boilers is effected by hand regulation through firing, draft manipulation, etc.; or by electric pneumatic regulators which take the place of the indicators.

Consider the problem simply: Let L_1 be the load in 1000 lb. of steam per hour on No. 1 boiler of a battery of six, L_2 the load on No. 2, L_3 the load on No. 3, and so on for all six.

Let L equal the power demand in 1000 lb. of steam per hour upon the whole battery. Then the ideal conditions again can be expressed in the form of simple equations: $\frac{L}{L_1}$ = Constant; $\frac{L}{L_2}$ = Constant; $\frac{L}{L_3}$ = Constant; $\frac{L}{L_4}$ = Constant; $\frac{L}{L_5}$ = Constant; $\frac{L}{L_6}$ = Constant.

Fig. 2 shows a curve produced by a recording steam-flow meter on one boiler of a battery of four. Note how the

*Power research engineer; laboratories, Pittsburgh, Kansas City and Zurich.

generation of steam fluctuates. These extreme variations are due not entirely to fluctuations in demand made by the prime mover. They are the result of a combination of causes, such as haphazard and illy timed firing, improper air supply, irregular feeding of water, etc., not only in the boiler from which this record was made but also in all the boilers feeding into the same line. This curve is a reproduction of what takes place in all the other boilers when no means are used to control the operations intelligently. The steamflow meter is an aid in remedying these conditions, but cannot perform the functions.

The nearest approach to perfect control with the aid of flow indicators comes when each boiler is supplied with an instrument that indicates continually the rate at which that particular boiler is generating steam. Then it is the business of the firemen to see to it that each boiler is carrying the same load under all variations of power demand. This, of course, he must do by hand manipulation—an arduous task even under normal conditions.

Before describing a plant equipped with the multiple-unit control it perhaps will be well to dwell more at length upon some analogies that exist between a well-controlled electric-generating plant and a steam-generating plant.

Both are generating a fluid under pressure to be used in some form of motor to do useful work. The voltmeter on the switchboard shows the pressure at which the current is supplied and can be likened to the pressure gage, which shows the pressure at which the steam is being generated. The ammeter shows the rate at which the current is doing work and can be compared to the flow indicator, which indicates the rate at which the boiler is generating steam. This simple analogy will serve to show the ease of functioning in the case of a single boiler supplying steam to a prime mover driving a single generator. The transformation of energy in the one is nicely reproduced in the other, and the efficient control of this simple unit is easily and readily accomplished. But in a large generating plant where a battery of, say, twenty-four boilers is feeding into a common header, which in turn furnishes steam to several prime movers connected to electric generators, all of which in turn feed into one feeder line, there is present the problem of efficient control, which does not exist in the case of the simple unit.

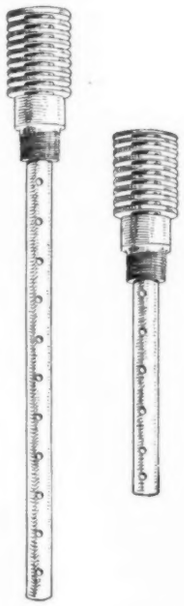


FIG. 3. NOZZLE PLUGS

At its best the steam generator is wasteful and inefficient, not utilizing 85 per cent. of the energy furnished to it in the way of fuel. From 10 to 12 per cent. of the energy of the fuel is consumed solely for the purpose of securing draft for free combustion by maintaining the requisite difference in temperature between the gases in the stack and the air at the entrance of the combustion chamber. Forced draft is a part solution for this problem. Then there are the losses due to illy timed and haphazard methods of operation which must be met and overcome by some centralized, automatic system of control.

In this article existing designs of boilers and furnaces are accepted and no improvements are offered or suggested, the purpose being merely to lay out a system of centralized control whereby all operations are correlated and cause and effect properly functioned. In the French Navy a system of control is used in which the officer on the bridge, by means of signals sent to the stokehold, indicates the rate at which the boilers should be fired to produce the steam necessary for the speed which he contemplates. Such a system has the advantage of being highly responsive if the organization is thoroughly harmonious, but would hardly be adapted to the modern power plant, where the load fluctuates widely many times a day, and where there is no man at the helm to give signals of an approaching peak or sudden drop. The safety valve is a good indicator for the latter condition, but has the disadvantage of being wasteful and noisy, and moreover is not quick to adjust conditions to the demands.

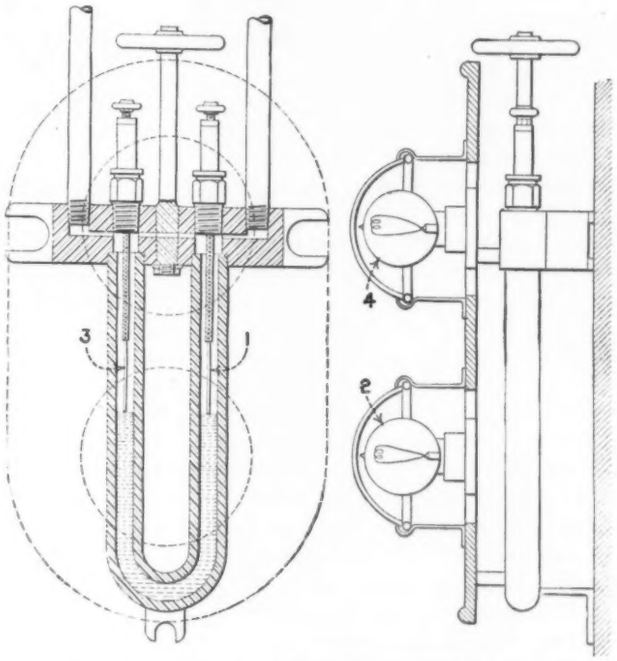


FIG. 4. SECTIONAL AND SIDE ELEVATIONS OF THE INDICATOR

Fig. 1 shows a general layout of a battery equipped with the multiple-unit control, the indicators on the boiler fronts being in plain view of the fireman. The nozzle plugs, two of which are shown in Fig. 3, are simple impact tubes screwed into holes tapped into the steam lines. The velocity of the steam in the header, due to the power demand of the prime mover, causes an increase in pressure in the pipe system connected to this tube. This increase is caused by the impact of the steam in the nozzle tube placed in its path of flow, and the flow is proportional to the square root of this dynamic head. This dynamic pressure communicates by means of the connections shown with the same side of each indicator. In each feeder line is inserted an impact nozzle similar to those in Fig. 3, which takes the impact of the flowing steam and transmits it as dynamic head or pressure to the other side of the indicator.

This indicator, as seen from Fig. 4, is a simple form of mercury U-tube, the columns being balanced by these two dynamic pressures, one pressure being due to the velocity of steam in the header line, and is the same in all the indicators, and varies only as the demands of the prime

mover fluctuates, and the other pressure is due to the velocity of the steam in the header line and varies only as the demand upon that boiler fluctuates.

When the system is in control, contact 1, Fig. 4, is grounded with the leg of the mercury column and green light 2 is burning. Immediately the system is not functioning properly, contact 3 is grounded with the other leg of the mercury column and light 2 is extinguished through contact 1 being cut out, and red light 4 is lighted, thus indicating the need of proper functioning of that particular boiler to meet the demands made upon it by the prime mover. Proper functioning is then obtained by hand manipulation, such as proper air supply, stoker feed, etc., until the green light appears and good conditions are indicated. Fig. 5 shows the complete instruments of the visual indicating type and Fig. 2 shows a general layout of the system as installed on a battery of three boilers supplying steam to a common header line. In the automatic control system, electro-pneumatic valves operated by the indicators are used to effect the manipulation of stoker speed and draft supply, and thus hand methods are dispensed with and good operation obtained.

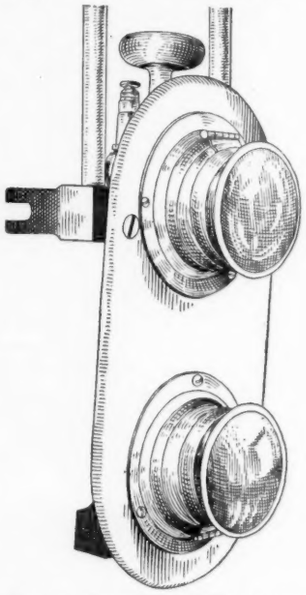


FIG. 5. CONTROL INDICATOR

The system has been developed at the writer's laboratory and is not available in the market.

Piston Rod Forces Air Into Refrigeration System

By C. E. Anderson

The engineer stated that the condenser pressure increased 5 lb. each day, and when I arrived I found it 250 lb., while the cooling water used was at a temperature of 56 deg. F. The pressure should have been 160 lb., using as they did 1 gal. of water per min. per ton refrigeration. Such a rise in condenser pressure can only happen where there is considerable air in the system. Air can enter through leaks and the stuffing box, but only when the suction pressure is reduced below that of the atmosphere, say in the case of pumping out. The engineer informed me that he never pumped out below zero, and I found the suction gage correct, at least as far as the zero point was concerned, by closing the gage cock and breaking the joint between the gage and the cock; the hand then stood at zero.

I then commenced blowing the air out of the condensers, using two stands of the condenser at a time, as I calculated that there was only sufficient liquid on hand to fill two stands. I ran the machine slowly until the hand of the gage advanced by sudden jerks, indicating the presence of a noncondensing gas (or practically noncondensing at such a pressure), which, of course, is in most cases air. Then I opened the purge valves and let the air escape until the outlet pipe commenced to frost and I could smell the escaping ammonia. The pressure then stood at 156 lb. Next I cleansed the other two stands of condensers, taking care that no gas containing air could enter the already purged ones, only drawing liquid from them to be able to fill the last two condensers. This satisfied the engineer, and I went away, telling him, however, that the only way the air could have entered was by the stuffing box, and that perhaps he had never pumped the system down below zero, but that one of his assistants might have done so.

A few days later the engineer wrote that the pressure was again increasing and that he examined the stuffing box carefully and found the cause of the trouble.

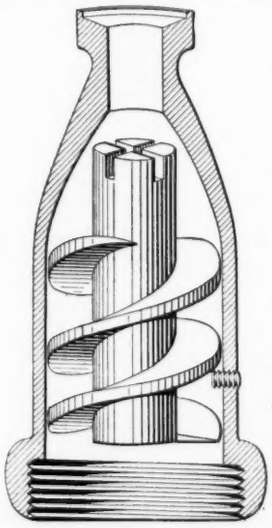
The compressor piston rods had worn badly and they had been turned off. For some reason the rods were not turned their whole length; consequently there was a shoulder on them about 6 in. from the crosshead. The shoulder entered the stuffing box about 4 or 5 in., which, of course, made an air compressor plunger out of the rod. Making 60 r.p.m., it would not take long to fill the system with air.

The lesson we learn from this is that when turning off a piston rod, turn it all the way up to the threads on the rod where it enters the crosshead, also bush the stuffing box gland and the neck ring in the compressor head to fit the turned-off rod.

The Binks Spray Nozzle

In the design of spray nozzles difficulty is encountered in producing a solid spray.

It is comparatively easy to produce a spray in the form of a hollow cone, cross, star or other semi-solid section. Such sprays waste space and are proportionately inefficient, requiring a greater cooling-pond area or washer volume for a given service, which increases the first cost and the subsequent cost of operation.



SECTION THROUGH SPRAY NOZZLE

The Binks nozzle, illustrated herewith, produces a spray which is a solid cone and therefore has an unusually high efficiency. The stationary spiral blade causes a perfect outer cone, while the hollow center tube, cross-slotted at the end, forms a straight spray, which, partly mingling with the whirling water of the outer cone, completely fills the interior. The manufacturers, the Star Brass Works, 319 N. Albany Ave., Chicago, have submitted this nozzle to comparative tests and are prepared to guarantee maximum efficiency and service.

Realigning a Belt-Driven Generator—The contributor calls attention to the fact that the slotted holes shown in the illustration on page 892 in the issue of June 29, should be lateral on one side of the angle iron and transverse on the other to give greater freedom of action for alignment.—Editor.

Editorials

The National Association of Stationary Engineers

This week the National Association of Stationary Engineers is holding at Columbus, Ohio, its thirty-fourth convention. Originating in the spontaneous getting together of a few kindred spirits to talk over power-plant problems and swap engineering yarns, progressing by the union of several such groups from different portions of the country into a national association, it has grown in a third of a century into an organization of upward of twenty thousand members, having 339 subordinate associations with one or more in most of the principal cities of the country, Idaho, Nevada, New Mexico, North Carolina and Wyoming being the only states in which there is no such organization. Their national convention assembles between four and five hundred delegates, and double that number of guests and camp followers. There are seventeen state associations holding annual conventions of the subordinate organizations in their respective jurisdictions, many of which conventions are greater in magnitude and of more importance than the national convention was during the first half of the life of the association. There is also an organization embracing all of the New England States with the exception of Connecticut.

From the very commencement the association had to combat the prejudice of employers, based on the mistaken idea that it was a labor union in disguise or the fear that it would develop militancy as its power increased. The engineers, however, who started the N. A. S. E. were men who would rather talk engineering than eat. They could get a whole evening's fun out of a blackboard and an indicator diagram, they were interested in cutting costs of operation, in improving efficiencies, in making records of runs uninterrupted by any fault of the engineer, in the organization and management of their staffs. They considered themselves in the executive class, as responsible heads of departments, and it was disconcerting and discouraging to have employers advise their engineers against joining and adopt that suspicious and guarded attitude toward it that they would toward an organization designed to attack instead of to conserve their interests. It was annoying to have governors, mayors and other public officials in addresses of welcome, with an utter failure to grasp the interest and purpose and significance of the organization, add to this misconception.

The misconception and suspicion were aggravated by the fact that they persisted in modeling the association upon the fraternal societies with which they were familiar, with passwords and other signs of recognition, although nothing ever transpires at their meetings which needs to be veiled in such secrecy. They did, however, positively state their objects and intentions in the preamble to their constitution, as follows:

This association shall at no time be used for the furtherance of strikes, or for the purpose of interfering in any way between its members and their employers in regard to wages; recognize the identity of interests between employer and employee, and not countenancing any project or enterprise that will interfere with perfect harmony between them.

Neither shall it be used for political or religious purposes. Its meetings shall be devoted to the business of the association, and at all times preference shall be given to the education of engineers, and to securing the enactment of engineers' license laws in order to prevent the destruction of life and property in the generation and transmission of steam as a motive power.

The language might be ironed out, but the intent is unmistakable, and the real nature of the organization is getting to be better understood.

The thirty-odd years that have passed since the first convention have witnessed great changes in power-plant engineering. They have seen the development of the multi-stage steam engine, the struggle of the internal-combustion engine to replace it; the rise of the steam turbine, the raising of steam pressures and the use of superheated steam. They cover practically the whole period of the industrial application of electricity. They have seen steam plants increase in size and complexity and importance until they require men of exceptional ability to manage and operate them; men who, with a thorough operative knowledge gained by actual contact and experience with the apparatus, combine a knowledge of the fundamentals which guides them aright when duty leads to unfamiliar paths; men who can manage men and get results. And it is the proud record of the National Association of Stationary Engineers that it has met the growing demand for this class of men, and many of those who are occupying positions of trust and responsibility today can credit to evenings passed at the meetings of the association the first gleams of the knowledge which fits them for their task and for the inspiration and aroused ambition which led them to round out that knowledge and find the place where it could be usefully applied.

Refinements in the Connors Creek Station

The individual efficiencies of modern steam and electrical apparatus, especially in large units, have been brought to a state permitting of little improvement through design; yet the steam plant as a whole is notoriously wasteful of the energy contained in the fuel. This is due to thermodynamic limitations rather than to shortcomings in the apparatus itself, and until we find some new method of utilizing this heat, the savings through eliminating preventable losses must be by a small margin. However, in a large steam plant these savings, while relatively small, are in themselves significant.

The Connors Creek plant of the Detroit Edison Company, described in this issue, represents an attempt to gather in stray heat units which in the ordinary plant escape unnoticed. The scheme outlined recovers the greater part of the heat radiated from the steam turbines and steam piping and the generator losses, this heat being returned to the boiler furnaces in the form of preheated air. Assuming the present equipment to

be operating at full capacity, the saving figures roughly, nearly a ton of coal per hour. At lesser outputs it would be proportionately less, but it would seem that a saving of probably two per cent. in the annual coal bill might reasonably be expected.

It appears that those responsible for the design of this plant preferred to sacrifice some of the heat in the flue gases rather than install economizers, which Professor Hirshfeld says were not considered a proper piece of apparatus for installation in a modern high-pressure plant, in view of the cast-iron tubes. That there is a difference of opinion on this important question is evinced by the fact that in the new Essex station of the Public Service Corporation of New Jersey, economizers have been installed. They are also used in the Fisk Street station of the Commonwealth Edison Company, of Chicago. The views of the men responsible for these installations would be enlightening.

Another feature of particular interest in the Connors Creek plant is the control of the feed-water temperature through the use of a barometric condenser on the auxiliaries as a feed-water heater; which thus affords great flexibility in maintaining the station heat balance.

In view of the boiler-room experience gained at the Delray stations and the refinements of the new plant, much is to be expected in the way of a new record in operating results.

Daily Commerce Reports

A commendable effort is being made by the United States Department of Commerce (Bureau of Foreign and Domestic Commerce) to make its daily trade reports of business enterprises and opportunities better known. The coöperation of numerous regular periodicals is being solicited and a circular letter is to be sent out to thousands of business concerns, a copy of which is reproduced on page 396. Incidentally, the case is by no means overstated.

The Engineering Congresses

Before this issue is in the hands of all of its readers the individual engineering conventions that are to precede the International Engineering Congress will be on at San Francisco. So will have been started a period of about ten days which will be notable in the annals of engineering history.

As stated in the program printed last week, the mechanical, electrical, civil and mining engineers will have meetings for three days—sort of preparatory training as it were. Then, after a couple of day's intermission, during which there will be opportunity to visit points of engineering interest, the big congress will open in full blast for its six-day meeting. It can safely be predicted that this will be the most important gathering of engineers that has ever taken place. The program offered is simply stupendous and represents months of work on the part of a very energetic committee.

Notwithstanding the serious handicap to the success of the congress which the European war has been, it will show its effect only in attendance, if at all. There have been provided as many papers as it will be possible to handle, and any engineer who can find it within his power to get to San Francisco during the sessions of this congress should not neglect to be there. In fact it will be well worth material sacrifice to get there for the meeting alone, to say nothing of the enjoyable and profitable trips out and back on the engineers' specials that have been provided. Taken all together, there is a wonderful month's treat in store for those fortunate members of the engineering profession who are going. Not a taste, scientific or just plain human, but will be gratified somewhere in the course of the experience. It may be safely characterized as a chance of a lifetime.

Auxiliary Turbine Exhaust

An interesting feature in turbine power-plant practice is that of utilizing the exhaust steam from auxiliary turbines in the second stage of the main turbine. This practice has so recently been adopted that little if anything has been published regarding the economic features over the old practice of exhausting the auxiliary turbines into a heater. Owing to plant design and operating conditions both turbine and motor-driven auxiliaries have found favor with engineers, and the newer utilization of exhaust steam will be, and is being, received with approval.

In some power plants all of the exhaust steam is so balanced with the amount of feed water requiring heating that the steam is practically all condensed in the heater. In other plants the auxiliary exhaust is excessive and much of it goes to waste.

The idea of exhausting the auxiliary units into the main turbine gives a flexible system which can be so piped that when desired the steam can be sent to the feed-water heater, or when the supply of exhaust steam is more than the heater can utilize it can be used to develop power in the turbine.

It cannot be stated what results have been obtained in using exhaust steam in this latter manner. Doubtless there are engineers who have records of past and present performances of their plant that will show the benefits derived from the latest practice, and it would be interesting to know just what difference is obtained in the operation of the plant by using the auxiliary steam in the main turbine instead of in the heater.

Oil that looked akin to molasses, but wasn't, has been used by some old-time engineers. Now, however, comes a German, H. Steffens, with a proposition (patented) to make a new lubricant from beet-sugar molasses, and from Hawaii comes a proposition to use molasses waste from sugar cane as fuel in competition with oil. So it looks as if we are to get sweetness mixed into our oil business some way.

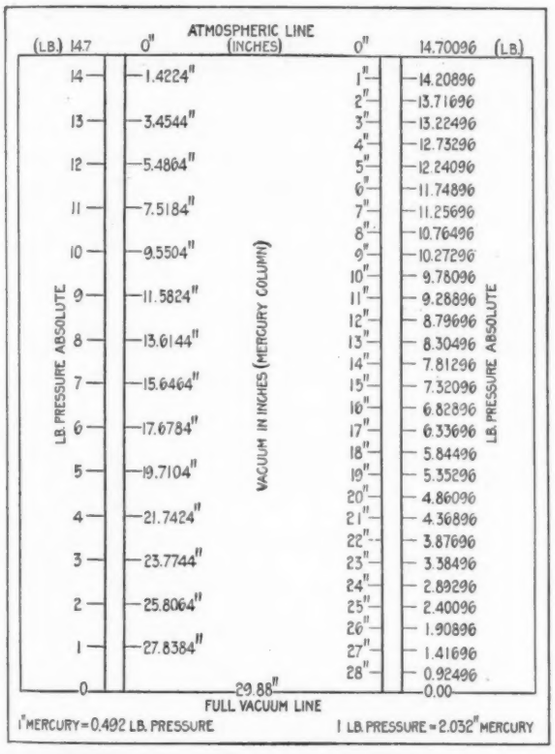
If a public-service corporation can legally charge, say, ten cents per kilowatt-hour for current used for lighting and three cents for current used for power, what is to prevent the customer from running a motor-generator with the three-cent current and making electricity with which to do his lighting? An English theater company has just put this over—and the court upheld it.

Don't crow too much over making an occasional good record in fuel economy, for you may have that same record "pulled" on you by the powers that be, some time when things are not going so well and be asked to live up to it.

Correspondence

A Handy Conversion Table for Low Pressures

A table showing the height of a column of mercury sustained by a given air pressure (in even pounds) and



COMPARISON OF PRESSURE AND HEIGHT OF MERCURY COLUMN

also the pressure necessary to sustain a column of mercury (in even inches) of a given height is printed herewith.

E. H. PETERSON.

Detroit, Mich.

Leakage of Superheated Steam

When the use of superheated steam was first advocated the argument urged for its adoption was the reduction to be secured in the loss from initial condensation in the cylinder. The saving thus effected is ample justification for the use of superheated steam, but as we become more familiar with its action it is discovered that there are other advantages pertaining to its use.

Superheated steam has a larger volume than dry steam at the same pressure, hence less weight is required to fill the cylinder at any given cutoff; and the extra heat needed to secure this volume is less than would be required to produce saturated steam to fill the same place. It has also been stated by the advocates of superheating that leakage through valves and past pistons is less for superheated steam than for saturated steam. This seems unreasonable at first glance, especially when we consider that grooves turned in the outside of the piston have been used in pumps and other machines as packing, the theory being that the grooves when filled with water would prevent leakage. An experiment for the purpose of proving or disproving this point has recently been made. Steam from a small boiler kept at 40 lb. pressure was led through a superheating coil heated by a gas flame, and thence to a brass cylinder 1½ in. in diameter by 2 in. high. In this cylinder was placed a brass piston about 1 in. thick, which was intentionally made an easy fit so as to allow for considerable leakage. A thermometer registered the temperature in the steam space inside the cylinder. Steam was introduced above the piston and a surface condenser was connected by a pipe with the space below the piston, so that whatever steam leaked past the piston would be condensed.

In the experiment with saturated steam the temperature was found to be 262 deg. F., which corresponds very closely to the pressure. For the superheated steam the temperature was 479 deg., a superheat of 217 deg. With the saturated steam 6 min. and 53 sec. was required to fill an 11-oz. flask with the condensation, while with the superheated steam 8 min. and 4 sec. was required, showing a reduction of leakage of about 21 per cent. by the use of superheated steam.

C. E. ANDERSON.

Quincy, Ill.

Vacation for Engineers*

From time to time there appear in *Power* articles relating to instructing substitutes and assistants to enable them to act in the chief's place in his absence. The following is my plan, starting at the bottom: If a fireman loses a shift or wants to get off for a day I put his coal-passer to firing and get a laborer to pass coal. If a shift engineer is off, I get the oiler to run, and bring in a fireman to oil, and so on, keeping up the rotation. If a fireman quits, the coal-passer longest in service gets the job, and a young laborer is hired to pass coal, thus keeping likely apprentices on hand. The oilers and shift engineers are promoted in the same way; so my plant is never in trouble for want of men. Whenever possible I carry an extra laborer at laborer's pay; then if a man is off I have one to put in his place, and as this man is paid by the hour he is always willing to substitute. I always insist that he be paid the wages of the man for whom he substitutes. This generally is a good investment, for it saves trouble and time hunting for a man at critical times.

The shift engineers take care of the actual running work, so that if I have to be away for a few days the plant will operate just the same. I always urge my men to rely on and use their own judgment and to look for the cause of any trouble that may occur. In this way they learn to be self-reliant and to look out for indications of trouble and correct them before damage is done. I have never

*See p. 162, Aug. 3, and Foreword, July 13.

found any advantage in acting in an aloof manner. I talk over the work, joke with the men and always consider myself one of the crew of workers, and often take a hand and help out, and when a boiler is cleaned I know as much about the inside of it as any man on the job.

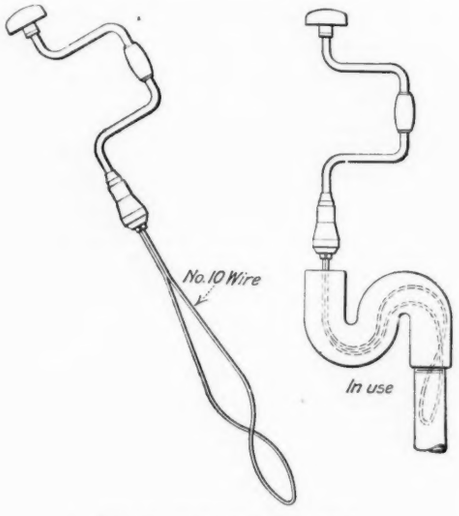
I have so often heard firemen say of others: "What does he know about firing? He never fired a scoopful of coal in his life." My men never say that of me. Instead, they say: "Well, if you can't hold steam up, get the chief; he will show you how; he has been there." And it is the same all the way through—a fellow-feeling.

A. A. BLANCHARD.

Ringwood Manor, N. J.

An Easily Made Trap Cleaner

A cleaner for waste traps that have become clogged can be readily made by the use of a brace and a steel wire, the thickness of the latter being about No. 10 B. & S.



TRAP CLEANER IN USE

The brace serves as a good holder and turner for the wire and its best feature is that the large sweep or leverage of the brace enables one to work the wire through the traps of the sinks, etc., with comparative ease.

A. P. CONNOR.

Washington, D. C.

Good Showing of Private Plants

The question of "Independent Plant versus Central Station" is constantly having additional arguments pro and con, in the shape of new and remodeled installations. The writer has always contended that in the North there should be no difficulty in meeting the central-station competition, even when this is hydraulic power, if the plant is properly designed and operated. If not, the central-station solicitor has an easy task.

Recently two small Corliss direct-connected engines were installed in a Providence hotel on a lighting load of less than 50 kw. Each engine is used 24 hr. alternately, and the present cost of current is less than 1¼c. per kw.-hr. when heating from the exhaust steam is credited. As this hotel had previously been paying a rate of over 3c., the saving is considerable. In that city there is keen competition from a distant hydraulic company, which has combined with the central company holding the franchise, and they boast that there will be no more isolated plants in Providence. A large store, however, has withstood their blandishments, and is quite successful, although not having the most uptodate apparatus.

Another mill plant in Pawtucket recently found it necessary to increase its power, the present unit being a 1000-kw. low-pressure turbine, but developing only about 750 kw. on the available exhaust steam. As the condenser and cooling tower were also of 1000 kw. capacity, another 300-kw. noncondensing turbine was purchased and will exhaust into the present large low-pressure turbine, thereby giving about 500-kw. additional capacity. Power was offered in this case at less than 1c. per kw.-hr., but it is expected that the mill will be able to produce power at about ½c. per kw.-hr.

To be sure, both these plants are somewhat special and do not involve new complete apparatus; but even so, the margin between central-station prices and costs is ample to allow for additional apparatus if required.

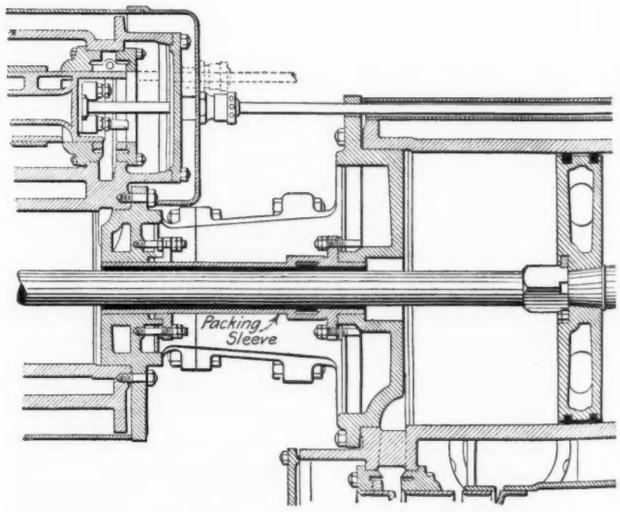
W. G. LONG.

Boston, Mass.

Metallic Packing Substituted for Packing Sleeve

I have a 15x26x17-in. tandem compound engine, which is run condensing part of the time. The illustration shows that a rather peculiar method of packing the piston rod was used. If this packing sleeve is in perfect condition it may be tight, but if not, there is likelihood of a serious leak.

I was soon convinced that the packing sleeve was leaking badly when the high-pressure cylinder was taking



THE ORIGINAL PACKING SCHEME

steam at 125 lb. at the crank end and the low-pressure cylinder was exhausting from the head end into a 26-in. vacuum. It would not take much of a leak to waste a large amount of steam, so I discarded the packing sleeve and put metallic packing in each cylinder. After the change it was possible to carry the load on two boilers in place of three.

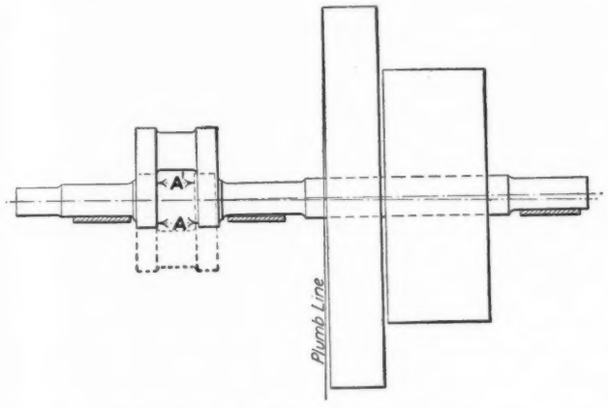
E. W. CREED.

South Braintree, Mass.

Broken Crankshafts

Several recent investigations of broken crankshafts of internal-combustion engines revealed the fact that the breakages were probably caused by faulty alignment of the outer bearing, which emphasizes the importance of having all of the bearings exactly in line.

The first case was that of a 40-hp. vertical oil-engine crankshaft breaking through one of the webs while the engine was running on a steady load, about three hours after starting up in the morning. The engine had done about seven months' work driving a centrifugal pump, and as there was no sign of an initial flaw in the material, and the shaft was working at a low calculated stress, it was decided to have the material tested. The results from two test bars showed that the steel was of a high quality,



STRAIN ON SHAFT AT CRANK

the breaking load being 34 tons per sq.in. and the elongation 28 per cent.

As the maker's report confirmed the test results it was decided to carefully inspect the engine now working with the new crankshaft. The outer bearing was running much hotter than usual, and the top brass of the main bearing on the flywheel side was also hot. A plumb-line dropped from the top edge of the flywheel indicated that the outer bearing was too high, although the machined part of the engine bed was level.

The crankshaft was removed and a piano wire stretched tightly through the bearings, when the outer bearing was found to be $\frac{5}{16}$ in. too high. There is no doubt that the breakage was due to the repeated bending of the crankweb every firing stroke. The outer bearing being high would cause the distance between the crankwebs to alter every revolution. The magnitude of the stresses on the crankshaft under these conditions cannot be calculated, and it is therefore necessary to take the greatest care to have all of the bearings correctly in line.

Lining up these bearings is not a difficult job if done before the crankshaft is put in place, but if the engine is sent out complete with the crankshaft in position then great care is required, and the only practical way is by the plumb-line method. But if the engine is not set perfectly level, allowance will have to be made, and it will be advisable also to check the distance, top and bottom, between the crankwebs, as indicated by the dotted lines in the illustration.

Another case of a broken shaft, also due to the outer bearing being too high, was on a smaller engine, which had been put down before the foundation was properly set, and the shaft broke in a few weeks. The bending, due to the outer bearing being either too high or too low, takes place in the crankpin close to the outer bearing side web, or in the web itself, midway between the pin and shaft, during each revolution.

Should the crankshaft have more than two main bearings on the engine bed, it will be necessary to see that these are in line before checking the alignment of the outer bearing.

A. VINCENT CLARKE.

Yeovil, England.

Erecting Machinery In a Foreign Land

In a reminiscent mood, looking back to my first foreign erection job, I will tell a few experiences in the hope that they may assist some other erector on his first job in the land of *mañana* and *caramba*.

It was just at the rear edge of the Tierra Caliente, where a rickety narrow-gage lumber and fruit road had thrown out a tentacle to grab a few dividends from a mine of low-grade stuff. The little terminal town, a turntable, a few dozen adobes, and the mine hung on the side of the *tierra alta*, were of small economic importance, not a promising field for investment in hydro-electric enterprises. But it was the birthplace of one of those hard-headed Indian statesman-warriors, the type of Porfirio Diaz to the north—who forgot not the balmy persuasiveness of white lights after his properly financed revolution had succeeded. *Por Dios!* The white lights of New York had charmed him. Should not his native town also be honored with a white way and the mine have electric power? To be sure they had water motors already installed costing nothing to operate when the water was free—but the mine manager was a *politico*, and did not a successful *generalissimo* say the electric power was superior? It surely would be discourteous to contradict such a distinguished señor, so a hydro-electric plant must be installed.

As a result of all the aforesaid, I found myself at the town with a sundry assortment of boxes reputed to contain two 150-hp. Pelton waterwheels, two 75-kw., three-phase, 2300-volt, belted generators; motors, wire, lamps, and copious instruction books. I say "reputed," for the sins of that custom house are probably of omission and commission. My own were entirely of commission, as I do not remember omitting any expression within my vocabulary which might have been in any way appropriate.

One evening each week a little wood-devouring locomotive, leaking steam at most of its rivets, poked the remains of its cowcatcher around a curve and wheezed alongside the adobe freight shed. The following morning it lumbered out again, protesting vigorously at every piston stroke, and another weekly epoch was ushered in and closed. Eventually all the generating equipment and most of the other material arrived, although the rheostats did not get there until long after I had started up with makeshift water rheostats.

But I am getting ahead of my story. The power house already built—selected is the accurate term—was a massive, walled adobe structure set on the river's edge, probably a fort of earlier days. The roof of tile, with gable walls missing, came about level with the railroad track.

A stock of ties was commandeered for skidway shoring, and a gang of *choles* set transferring them to position. Not satisfied with the way these fellows handled the ties, I endeavored to inject some "efficiency engineering." They took kindly to this, watched me closely, commented *muy fuerte,* but didn't offer to continue the process, imitating a full strike in progress. The mine superintendent came along about that time and told me that for these fellows to continue doing that kind of work would be a serious breach of etiquette; it was as the work of *padrones.* My only recourse was to fire the entire gang, get a new crew and never touch my hands to any work that the laborers were doing, after which things again began to move smoothly.

The thick walls of the power house seemed made especially to carry heavy loads, and with timbers and the 20-ton chain blocks rigged, high hopes were indulged in; but instead of the machinery swinging as expected, the timbers began to crush into the adobe wall. It was then I learned how little compression strength sun-dried mud has.

With machinery installed, a pole line built to the mine, and a few lights strung among the adobe shacks, the "central station" was complete. Each evening the second waterwheel was started and the generators synchronized by lamps, which were wired to indicate synchronism when dark. One dark-skinned little relative of the afore-mentioned *generalissimo* had been selected as chief operator and was taken carefully through the program of starting up. Time after time, without a word of prompting, he had successfully started the second unit, and paralleled the generators. One evening, however, the young hopeful started his program as usual, when "bang!" went the oil switch when the synchronizing lamps were at their brightest. The belts screamed and in wild contortions twined about the wheel casings. The would-be operator gave one wild shriek and plunged headlong through a nearby window—the door was too far for him. I think he must be running yet, for I never saw him again.

WALTER SWAREN.

Hayward, Calif.

Direct-Connected Fans

There is perhaps no service in which the direct-connected motor drive shows up to greater advantage than in driving fans or blowers. Large fans require considerable power, and because of the high speed and the heavy power requirements with comparatively small pulleys (which make it difficult to keep belting in good order and have it perform its full duty), they are among the most difficult machines to drive with belts.

An example of what may be accomplished in the way of economy, as well as reducing the worry and trouble of maintenance, was observed in a plant using a twin-fan blower system driven by a motor set 10 or 12 ft. away and belted to the fan. The belt gave considerable trouble and the engineer advised a direct-connected motor.

In order to obtain data of the power consumed before and after the change the engineer took the average power load on the motor driving the fan with a belt and found that it was from 100 to 125 hp.

After making the change he found that only 75 hp. was being used, saving from 25 to 40 per cent. by eliminating the belt drive and making a direct connection with the motor. Moreover, the speed of the fan was more steady.

The engineer found it a little difficult to explain the reason for this power saving, but the saving was there. He had satisfied himself of that by tests before and after the change. He thinks that the main power loss was caused by the belt slipping considerably and this called for higher speed on the part of the motor to maintain the desired speed at the fan, which meant the use of more power; and of course there was friction loss in the belt and in the strain of the belt on the journals of both the motor and fan.

Fans and blowers as a rule consume much more power than those operating them think they do, unless the operators take the trouble to test them out and measure the power consumption. That is one of the things electric transmission has brought—a better understanding of the exact power requirements of all kinds of machines and that fans and blowers are large power consumers, which makes it all the more important to connect them directly and take all steps that are practical for power economy in their operation.

J. CROW-TAYLOR.

Louisville, Ky.

Author's Correction Regarding Centrifugal Pumps

In Fig. 62, p. 90, of the writer's book, "Centrifugal Pumps," a cross-section is shown of a De Laval centrifugal pump provided with labyrinth wearing wings of the "radial" type. This is an error, as all pumps made by the De Laval Steam Turbine Co. are equipped with the "axial" type of labyrinth rings.

The "radial" type is the invention of Albert E. Guy, who also was the designer of the "axial" rings used by the De Laval Steam Turbine Co. The radial labyrinth rings of Mr. Guy are used exclusively by the Wilson-Snyder Centrifugal Pump Co. and the Providence Engineering Works.

R. L. DAUGHERTY.

Ithaca, N. Y.

Worn Stoker Chain Injures Brickwork

In the plant where I am employed we had considerable trouble with the coking arches of the furnaces under the B. & W. boilers equipped with chain grates. Grooves would be cut clear through an arch in four or five weeks and necessitate its renewal.

Eventually the cause was found to be in the chain grates, which are 12 years old, and being worn had developed enough side play to let the links ride on the sprockets and slip to one side, more or less, leaving an opening ½ to ¾ in. wide all along the grates, and the blow torch action of the air rushing through would draw the flame from two sides and produce such an intense heat that brick and mortar could not withstand it very long.

After taking the grates apart and inserting extra links, four abreast, we have grates as good as new, very little coal runs through, and the arches last from 12 to 16 weeks.

A. BLOM.

Chicago, Ill.

Inquiries of General Interest

Spontaneous Heating of Coal—What causes spontaneous heating of stored coal?

G. K.

Spontaneous heating results, not from a self-contained fermentation-like process within the coal, as commonly understood of spontaneous combustion of materials which are said to heat, but from the slow oxidation of the coal substance or its mineral impurities by the oxygen of the air. Hence spontaneous heating does not occur when air is excluded from the coal, as when it is submerged under water.

Negative Slip of Propeller Screw—What is meant by the negative slip of a propeller screw?

N. T.

When a screw-propelled vessel moves farther through a body of water than if the screw turned in a stationary nut, then the screw is said to have negative slip. The term negative slip, however, is misleading, as the acceleration is acquired, not by the operation of the screw in the main body of water, but by its reaction against water that is dragged forward by the motion of the vessel.

Brass-Polishing Paste—What is a good receipt for compounding a paste for polishing brasswork?

J. L.

A brass-polishing paste, said to give satisfactory results, is composed of camphor gum, 1 oz; alcohol, 2 oz.; spirits of ammonia, 2 oz.; spirits of turpentine, 4 oz.; candle paraffin, 1 lb.; clean tallow, 1 lb.; tripoli, 1 lb. For compounding, first dissolve the camphor in the alcohol, then melt down the tallow and paraffin and stir in the liquids and the tripoli. Before cooling, the paste can be packed in boxes of sizes convenient for use.

Single- vs. Double-Pipe Systems of Steam Heating—What are the relative advantages of single-pipe and of two-pipe systems of steam heating?

J. S.

The main advantages of a single-pipe system are greater economy in first cost, saving of pipe space, employment of a single valve on each radiator and less waste of heat where the pipes pass through spaces that require no radiation. The advantages of a double-pipe system are the possibility of securing more positive circulation and the opportunity of blowing out a system to clear it of dirt or to free it of air for starting quickly or for operation as a vacuum system.

"Force of a Blow" Is Indeterminable—If a car weighing 4,000 lb. and running at the rate of 15 miles an hour should strike a stationary object weighing 250 lb, what would be the force of the blow in pounds?

G. N. L.

Impact of one body upon another cannot be computed in pounds of force or pressure, as the foot-pounds of energy absorbed is employed in imparting motion to the body struck, in penetration against friction or against shearing or other deformations, and in crushing and heating of both bodies. The distances through which these resisting forces act is generally indeterminate, and therefore their average is indeterminable.

Detecting Animal or Vegetable Adulterants in Mineral Lubricating Oils—How can animal or vegetable adulterations in mineral lubricating oils be detected?

R. F. R.

A simple way to test for such adulterations is to take a glass test tube about one-third full of the oil to be tested and add an equal quantity of a saturated solution of borax and water. Upon shaking the liquids together, if animal or vegetable adulterants are present they will appear in the form of a milk-like emulsion, which will separate out when allowed to stand, the pure mineral oil appearing at the top as a clear liquid and the excess of borax solution at the bottom with the emulsion between the oil and the excess borax solution.

Boiler Steam Space per Horsepower—What should be the volume of steam space per horsepower of a boiler?

W. R.

The usual volume per horsepower ranges from 0.6 to 0.8 cu.ft., and in some designs of boilers 1 cu.ft. of steam space per horsepower is found necessary for obtaining a good quality of steam. The volume per horsepower depends upon the rapidity with which the steam is withdrawn, whether a dry pipe is used and the disengaging surface at the normal water level. The more rapid the withdrawal of steam and the smaller the disengaging surface the greater should be the steam space, as restricted steam space is conducive to wet steam and to foaming if the boiler is driven hard.

Diameter of Cylinder Required to Develop Stated Power—If the stroke of an engine is 14 in., what would be the required diameter of cylinder to develop 109 i.hp. at 260 r.p.m. with a mean effective pressure of 62 lb. per sq.in., allowing for a piston rod $\frac{1}{6}$ the diameter of the cylinder?

F. C. M.

The formula for the horsepower is

$$\frac{P \times L \times A \times N}{33{,}000} = \text{H.P.}$$

in which

P = Average pressure per sq.in.;
L = Length of stroke in feet;
A = Area of piston;
N = Number of single strokes.

Calling d the diameter of the cylinder in inches and $\frac{d}{6}$ = the diameter of the piston rod, then the area of the piston would be $d^2 \times 0.7854$, the area of the rod would be

$$\left(\frac{d}{6}\right)^2 \times 0.7854,$$

and the net area of the crank side of the piston would be

$$\left[d^2 - \left(\frac{d}{6}\right)^2\right] \times 0.7854 = \tfrac{35}{36}\, d^2 \times 0.7854.$$

As there would be 260 strokes of each side of the piston, then by substitution, the formula becomes

$$\frac{62 \times 1\tfrac{1}{6} \times (d^2 + \tfrac{35}{36}\, d^2) \times 0.7854 \times 260}{33{,}000} = 109,$$

or d = 11.1 in. diameter.

Preparing Heating Boiler for Service—What should be done to place a heating boiler in commission?

E. A. M.

Clean the boiler thoroughly on the fire side if it was not done in laying up the boiler in the spring, and examine and clean the smoke pipe and damper of rust and corrosion. With cast-iron sectional boilers, the corrosion formed between the sections may have rusted badly from accumulation of moisture during the summer season. Any rust thus formed should be carefully removed, as upon expansion of the boiler from heat its presence is likely to result in fracture of the sections. Rust spots discovered on the outside of the boiler or heating surfaces should be thoroughly cleaned with a wire brush and painted with a mixture of red lead and boiled linseed oil. Make all necessary repairs to setting, grates, fire and draft doors and pressure regulator to put them in first-class condition, as repairs of the kind are conducive to coal economy and convenience in operation of the boiler.

The inside of the boiler should be cleaned of all rust, scale and sediment and washed out as well as possible with a hose. The boiler should then be emptied and after introducing a few gallons of kerosene oil, fill with water very slowly so that the oil will reach all portions of the interior surface. Add a few pounds of dissolved carbonate of soda to the water and when the boiler has been completely filled, draw down the water to the ordinary steaming level. Then carry a very slow fire for several days with the safety valve blocked open, never raising the pressure higher than necessary for barely indicating an escape of steam at the open safety valve. This will loosen the scale and sediment, but before the boiler is put into service, it is especially important that the interior of the boiler and the safety valve, feed and blowoff valves, gage-cocks, steam gage and water column and connections should be washed perfectly clean and put in first-class working order.

[Correspondents sending us inquiries should sign their communications with full names and post-office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Connors Creek Power Plant*

By C. F. Hirshfeld†

SYNOPSIS—New plant of the Detroit Edison Co., in which two of a total of six 25,000-kv.-a. generating units are now installed. Two boilers similar to those at Delray serve each turbine. Stokers are of the underfeed type, with 26 retorts per boiler. The coal-handling equipment is electrically operated and the starting devices are interlocked so that various motors must start in proper sequence. The piping systems have a number of interesting features, the surface condensers have no baffles and special provisions have been made to supply and control the circulating water. Make-up water is distilled, and the condensate is heated and stored by a special house-service system utilizing a barometric condenser on the house alternator turbine as an open feed-water heater. The temperature is regulated by varying the back pressure. All auxiliaries except the boiler-feed pumps are motor-operated. The main generator leads are tied solidly to the transformers and no reactances are used for protection against short-circuits.

The phenomenal growth of Detroit's population and industries has been widely heralded, but it is probable that the extent of this growth and its significance to the central-station industry are not appreciated by those not closely in touch therewith. The curves of Fig. 1 are given for this reason. The upper curve showing the variation of population during the past decade is approximately correct, because it fits smoothly into the curve obtained by plotting United States census figures and because it checks closely with the more accurate of the estimates which have been made from time to time. This curve indicates that the population of Detroit in 1914 was about 1.6 times as great as it was in 1904, just ten years before.

The annual output of the central stations, as given by the next lower full-line curve, has increased more rapidly than the population. In the year 1914 it was about 21.4 times as great as in 1904. The fact that the maximum annual peak was only ten times as great in 1914 as in 1904 indicates that a large part of the increased annual output was due to increased industrial application. This is also partly indicated by the curve showing the variation of load factor.

Before the Connors Creek plant was built practically all of the generating equipment of the company was contained in the Delray power houses Nos. 1 and 2, having an aggregate maximum capacity of about 95,000 kw. They are adjacent to one another and operate as one plant. When it became evident about 1912 that greatly increased capacity would soon be required, two possible solutions were available—a third power house could have been built at the Delray site or a new site could be selected.

Consideration of the direction of growth of the city during the past 10 years; the rapidly increasing population and industrial development of the East Side; the location of the heavy direct-current load; necessity for continuity of service, with an ever-increasing complexity of distribution system fed through one point near what might be called a corner of the city, and numerous similar items resulted in the choice of a new site, despite the many duplications which such a choice involved. The transmission loss in underground cables of a mean length of 7 mi. required to serve the growing East Side manufacturing district and the fixed charges on these cables and their conduits were by themselves almost sufficient to determine the choice of the site selected.

As the new site is on the riverfront, excellent condensing water is available in enormous quantities. In this respect it is even better situated than the plants at Delray, as the river flows from the newer toward the older site and picks up all the sewage of the city while passing the waterfront.

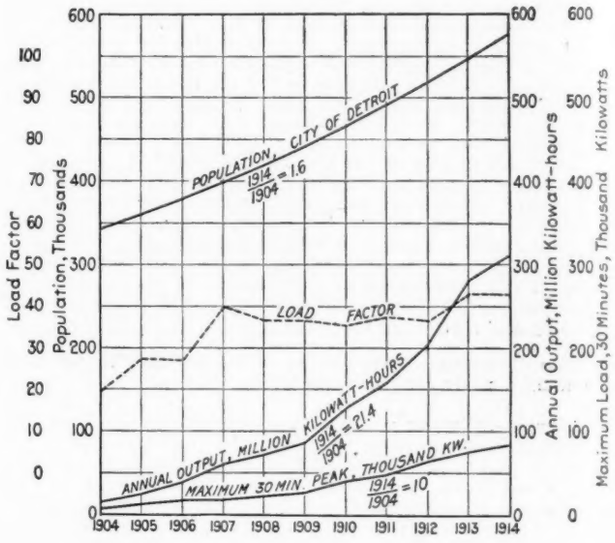

Load Factor
Population, Thousands
Annual Output, Million Kilowatt-hours
Maximum Load, 30 Minutes, Thousand Kilowatts
POPULATION, CITY OF DETROIT
1914/1904 = 1.6
LOAD FACTOR
ANNUAL OUTPUT, MILLION KILOWATT-HOURS
1914/1904 = 21.4
MAXIMUM 30 MIN. PEAK, THOUSAND KW.
1914/1904 = 10
1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914

FIG. 1. CHART SHOWING INCREASE IN LOAD AND POPULATION SINCE 1904

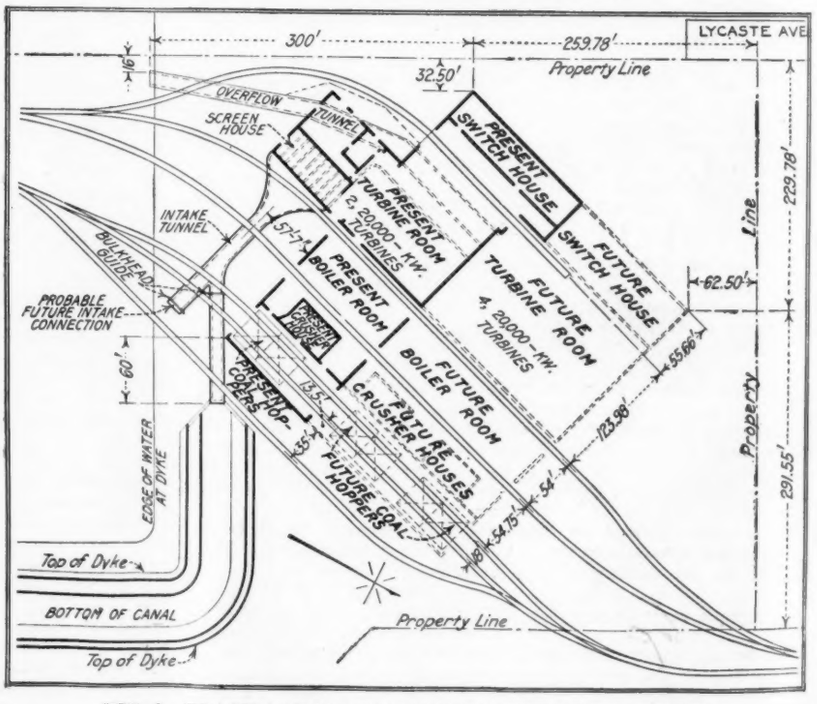


FIG. 2. TRACK LAYOUT AND PLAN OF BUILDING AT THE CONNORS CREEK PLANT

*From a paper presented at the Buffalo section of the American Society of Mechanical Engineers.

†Chief of research department, the Detroit Edison Co., Detroit.

Being at the river end of a terminal railroad, the new site can be supplied with coal as easily as the old site, and if water transportation of coal should become advisable, both sites are equally well located.

The Connors Creek site is large enough to accommodate two power houses, each with greater capacity than that of the two plants at Delray combined. The first house was planned to accommodate six 25,000-kv.-a. units, but it seems probable that this unit size will be increased before the last units are installed. The plan of this house, together with

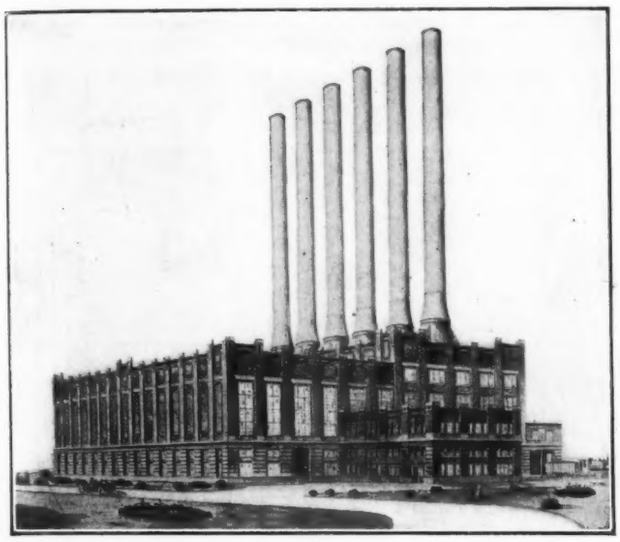


FIG. 3. CONNORS CREEK STATION AS IT WILL EVENTUALLY APPEAR

the canals and tracks which serve it, is shown in Fig. 2. The river is located beyond the left-hand side of the drawing and runs in a direction roughly parallel to the left-hand end of the plate, and upward. The diagonal position of the plant was dictated by the shape of the site, the necessity of leaving room for a future power house, the curves required for railroad tracks, and the location of the river, which determined the direction and location of the canals. One-third of the first power house on the Connors Creek site has been built and two of the proposed six units are installed. The building is closed with a temporary end, so that the machinery now installed can be operated until and while future extensions are being constructed. The intake and overflow canals are completed in full size for six units.

An architect's drawing of the finished power house is given in Fig. 3 and a sectional elevation in Fig. 4. The latter shows the construction to best advantage and should be consulted in connection with the description which follows.

Coal Handled Electrically, Special Control

Coal enters the train shed in drop-bottom cars (usually of the 50-ton size), which move on the lower group of tracks shown in Fig. 2, after being weighed on the railway scales located near the upper left-hand corner. The cars dump into hoppers under the tracks in the train or coal shed, there being one hopper for each unit of one turbine and two boilers. A motor-driven variable-speed flight conveyor, with a capacity of 120 tons per hour, receives the coal from the hopper, carries it up a rather sharp incline and discharges it into a four-roll motor-driven crusher of similar capacity. This crusher breaks from 18-in. cubes, or smaller, to that which will pass through a 1¾-in. ring.

The crusher discharges directly into a motor-driven constant-speed lapping bucket conveyor with 30x36-in. buckets. This conveyor forms an endless chain which entirely incloses the section of the boiler house, as indicated in Fig. 4. It carries the coal up on the side nearest the coal shed and discharges it into any one of the three coal bunkers which serve the two boilers of one unit. The hopper, pan conveyors, crusher and bucket conveyor for each unit of one turbine and two boilers are so located that they can deliver through chutes to one adjacent range of bunkers, serving thus as a spare for that range.

The entire coal-handling equipment is electrically operated, and the control is centralized at a board in the coal-crushing room. Starting devices are electrically interlocked so that the various pieces of apparatus must start in proper sequence. Provision is also made to prevent starting until an observer on the floor above the coal bunkers has determined that the exposed, upper, horizontal run of the bucket conveyor is clear and has so indicated. Emergency buttons are provided at numerous points along the run of the bucket conveyor. Pushing any one of these stops the entire system, and it cannot be started again until that particular emergency button has been reset by means of a key. The custodian of this key is therefore the only individual who can start the system after an emergency stop, and even then he must go to the point from which the stop was made.

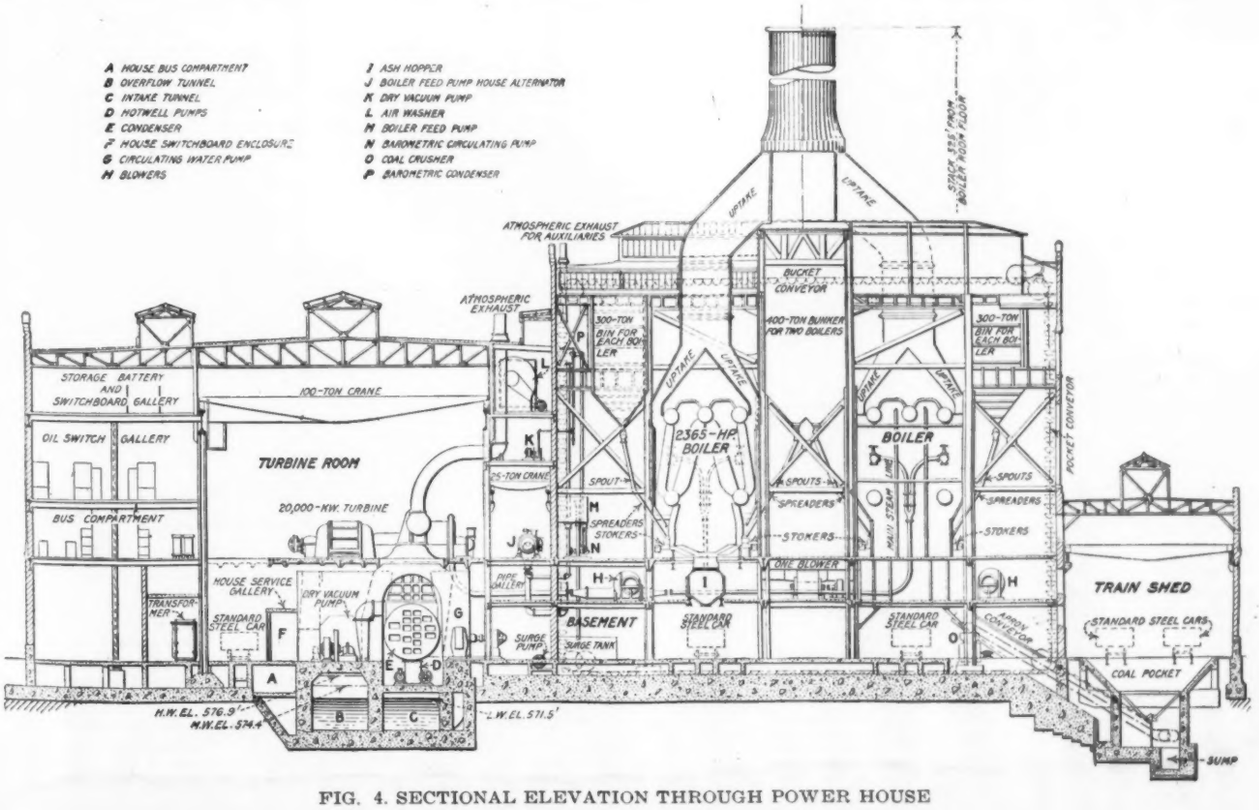


FIG. 4. SECTIONAL ELEVATION THROUGH POWER HOUSE

After the coal has been dropped into the bunkers it descends by gravity to the stokers. The latter are of the underfeed, sloping fire-bed variety, and there are twenty-six retorts per boiler. These are arranged in two groups of thirteen each, the boiler being fired from the two ends as shown in Fig. 5. Ash and clinkers are removed by two clinker grinder bars located in a sort of pit running across the center of the furnace and are discharged into the ash hopper. This is an inclosure within the wind box or plenum chamber below the boiler and holds the refuse until it is finally dropped directly into standard railroad cars which run lengthwise of the house directly under the ash hoppers.

The stokers are driven through chains by direct-current motors, the speed of which can be varied from 200 to 2000 r.p.m. This wide range of speed is obtained by means of voltage change from 125 to 250 volts combined with field control. The motors are handled by means of drum controllers located at the gage board of the particular boiler which they serve, and electric tachometers are used to indicate stoker speeds at this board.

Forced-Draft System

Motor-driven blowers supply the air required for combustion, there being three of these blowers per range of two boilers. One of the three serves as a spare and is located between the two boilers. It is arranged to discharge either way through a Y-shaped duct. All of the blowers discharge through expanding ducts, which are designed to recover the greatest possible fraction of the velocity head. These large ducts lead into a plenum chamber with a horizontal section equal to the furnace. The stoker wind boxes form part of the roof of this chamber, so that the air passes directly from the plenum chamber to the stoker and does not have to pass through small ducts of any kind. Each blower is designed to deliver a maximum of 74,000 cu.ft. of air per min. against a static pressure of 6.5 in. of water. The motors are shunt-wound and are direct-connected to the blowers through flexible couplings. Their speed can be varied from 300 to 750 r.p.m. The drum-type controllers are mounted at the gage boards of the boilers served, directly under the gages which indicate the static pressure in the plenum chamber.

Boilers Similar to Those at Delray

The boilers are similar to those used in the older plants at Delray, but are set 3 ft. higher, so that the height of the combustion chamber is 33 ft. These boilers each have 23,654 sq.ft. of water heating surface and are built to operate at a pressure of 225 lb. per sq.in. The superheaters have about 2400 sq.ft. of surface and are designed to give a superheat of 200 deg. F. at 200 per cent. of rating.

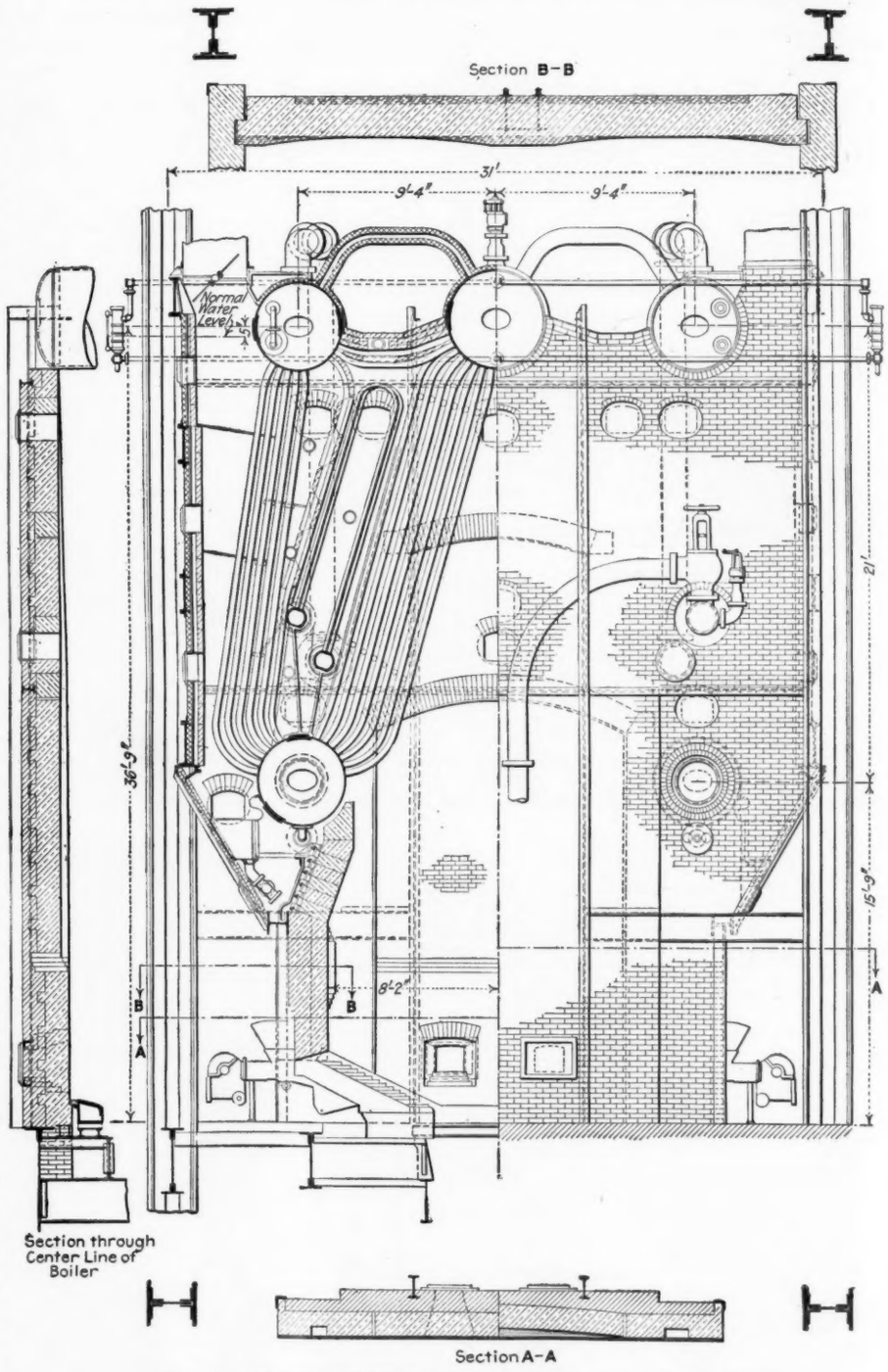


FIG. 5. BOILER SETTING WITH SECTIONS OF WALLS

The gases, leaving the dampers at the top of the boiler setting, pass upward through easily curved breechings and into the steel stack near its base. This stack is supported entirely on the steelwork of the boiler-room structure and extends to a height of 325 ft. above the floor on which the stokers are located. It has a height of about 240 ft. above the roof of the boiler house. The stack is brick-lined and has a diameter of 16 ft. inside of the lining.

As already mentioned, there are only two boilers per turbine. When operating the turbine at full load the boilers will operate at about 170 per cent. of Centennial rating. In the ordinary sense there are no spare boilers. Experience has shown, however, that these boilers can be safely and economically operated at ratings considerably in excess of 170 per cent., and provision has been made to enable three boilers to supply steam to two turbine units. When carrying full turbine loading under these conditions each of the three boilers will have to operate at about 225 per cent. of rating.

The main live-steam piping consists of a run from two boilers to the unit which they serve, all of these runs being cross-connected by a crossover header. This piping is located in the pipe gallery below the stoker floor, except, of course, the leads dropping down from the boilers and rising to the turbine throttles.

From each boiler the steam leads are 10 in., and these join in a Y fitting which has a 14-in. discharge. Under full-load conditions, with two boilers supplying one unit, the steam velocities will be about 10,500 ft. per min. in the 10-in. pipe and 12,000 ft. per min. in the 14-in. pipe. With three

boilers supplying two units these velocities will rise to about 14,000 and 16,000 ft. per min. respectively.

The proposed use of the crossover main necessitated a design which should permit steam from any two boilers to flow into that main, and steam from the main to flow into any turbine lead, with practically equal facility. After many designs had been considered, that shown in Fig. 6 was adopted. The steam leaving the 10x14x10-in. Y branch previously mentioned passes through a cast-steel expanding nozzle which enlarges to a diameter of 28 in. This, in turn, leads into a 28-in. cast-steel side-outlet T or side-outlet cross. The 28-in. lateral outlets of the latter fittings are the connection points of the crossover main. The velocity of the steam passing into the crossover, or from the crossover main to the turbine lead, is thus reduced to about one-quarter of its value in the 14-in. pipes, or, roughly, a little less than 4000 ft. per min. under the worst conditions. The steam turns through the necessary right angle at this low velocity, and therefore with small loss.

Steam leaving the 28-in. fitting on its way to the turbine is carried through a tapered reducer with a discharge diameter of 14 in. Similarly, steam leaving the 28-in. fitting on its way to the crossover main passes through a tapered reducer which is cast with its longitudinal axis in the shape of a quarter circle. This reducer leads the steam into a 14-in. return bend, as shown in Fig. 6. The steam for the auxiliary turbines, which will be mentioned later, is taken from a 6-in. outlet on top of the 28-in. fittings previously described.

All superheated steam piping is full-weight steel with welded flanges. The flanges are finished smooth, and corrugated steel gaskets are used. All fittings are cast steel. At the Delray plant Hopkinson-Ferranti valves with venturi throats were used. These have been found to cause an excessive pressure drop because of the short length of the expanding nozzle and were therefore not deemed desirable for the new plant if an equally reliable, full-opening form could be found. Full-throated gate valves made by Hopkinson of the same material as the Ferranti valves were therefore used in the Connors Creek plant.

The atmospheric exhaust lines of the main units are made of riveted-steel pipe and fittings. The auxiliary exhaust piping is lap-welded steel with Van Stone joints and fitted with corrugated copper gaskets. All valves in the exhaust lines are steel gate valves of American make. All saturated-steam piping is extra-heavy steel fitted with steel flanges. The fittings are all cast steel, and steel valves of American make are used.

Steel Pipe for Feed Water

The feed-water piping is extra-heavy, lap-welded steel, with Van Stone joints and cast-steel fittings. The use of steel pipe throughout for the feed water represents a marked departure from Delray practice, in which brass pipe was used for the boiler leads and connections. In laying out the feed-water system at Connors Creek the design was so arranged as to permit of free expansion without the use of expansion joints of any kind.

The boiler blowoff valves are also made by Hopkinson. These were decided on after two of them had been in satisfactory operation for several years at Delray. The valve is a parallel-seat gate, on the stem of which is cut a rack which meshes with a pinion. A 180-deg. turn of the handle turns this pinion through a like angle and fully opens the gate. The superiority of the valve appears to be due to the use of excellent metal and to high-class machine work.

Main Generating Units

As previously mentioned, the main units are rated at 25,000 kv.-a. or 20,000 kw. at 80 per cent. power factor. The steam end consists of a horizontal nine-stage turbine making 1200 r.p.m. The electrical end generates three-phase 60-cycle current at 4800 volts. A section of the turbo-generator unit is shown in Fig. 7. The steam exhausted from the turbine passes down through a large expanding exhaust nozzle into

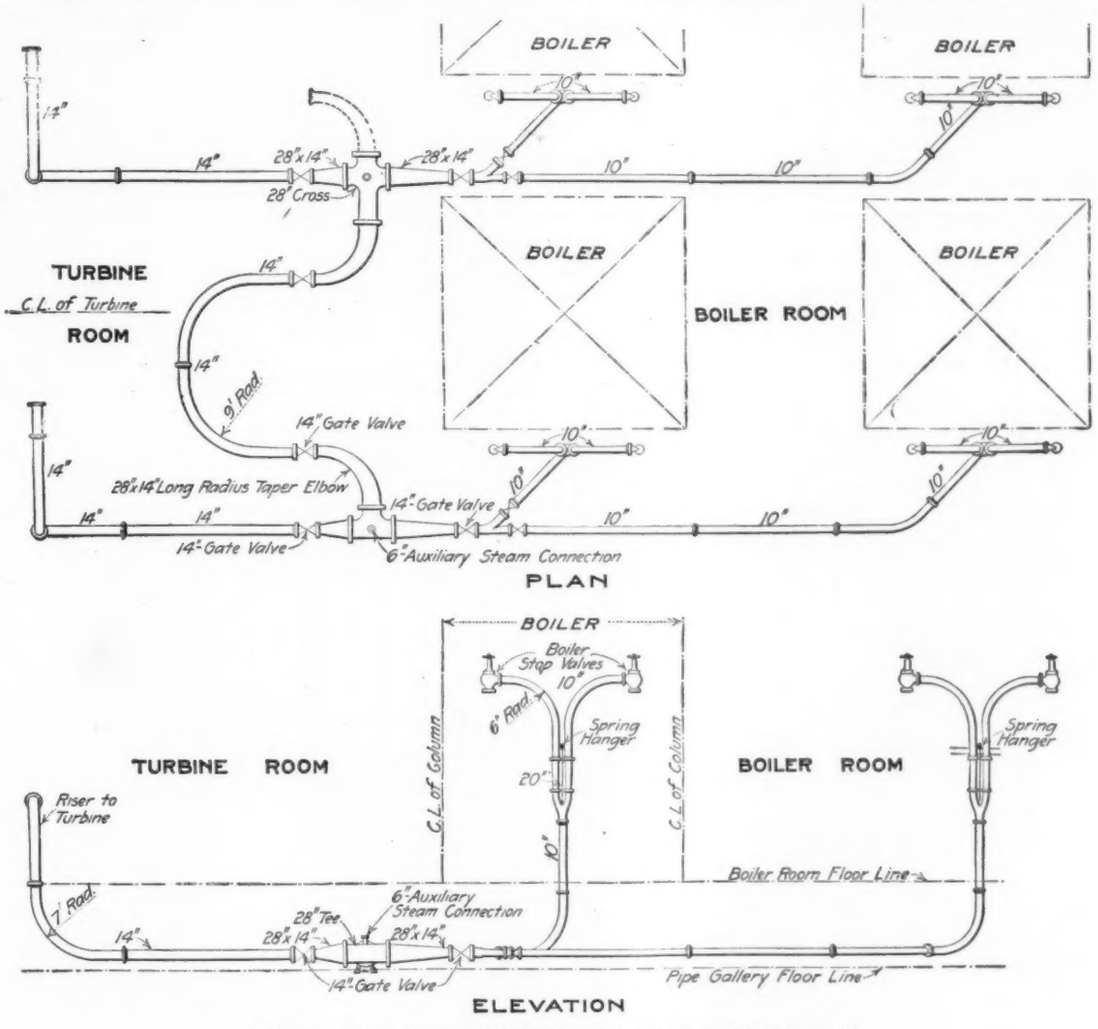


FIG. 6. PLAN AND ELEVATION OF MAIN STEAM PIPING

the condenser, as shown in Fig. 4. Each condenser is built to contain 35,000 sq.ft. of heating surface made up of 1-in. tubes a little over 18 ft. long, but has only 32,500 sq.ft. installed. The tube heads have a diameter of 14 ft. 6 in.

The tubes are so arranged as to leave numerous lanes through the steam space, so that the vapor and air readily flow to all parts of the cooling surface. No baffles of any kind are used except those necessary to form an air box. The latter is located at the bottom of the condenser, as indicated in Fig. 8.

The condensate collects in a cylindrical hotwell which extends from the lower part of the condenser shell; and it is removed by either one of two hotwell pumps. These are motor-driven two-stage centrifugal pumps operated at 1200

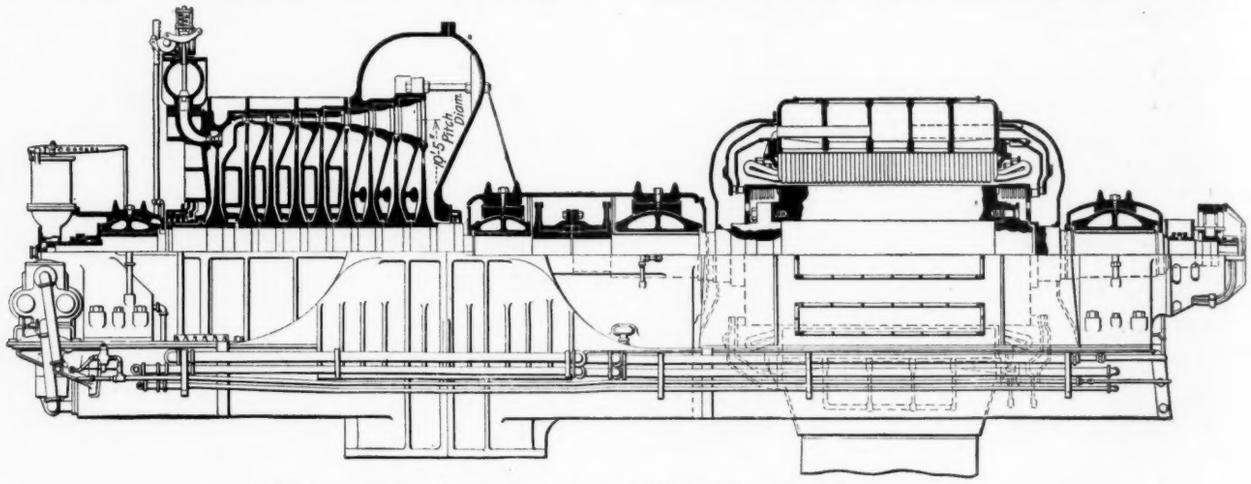


FIG. 7. PART SECTION THROUGH 20,000-KW. TURBO-GENERATOR

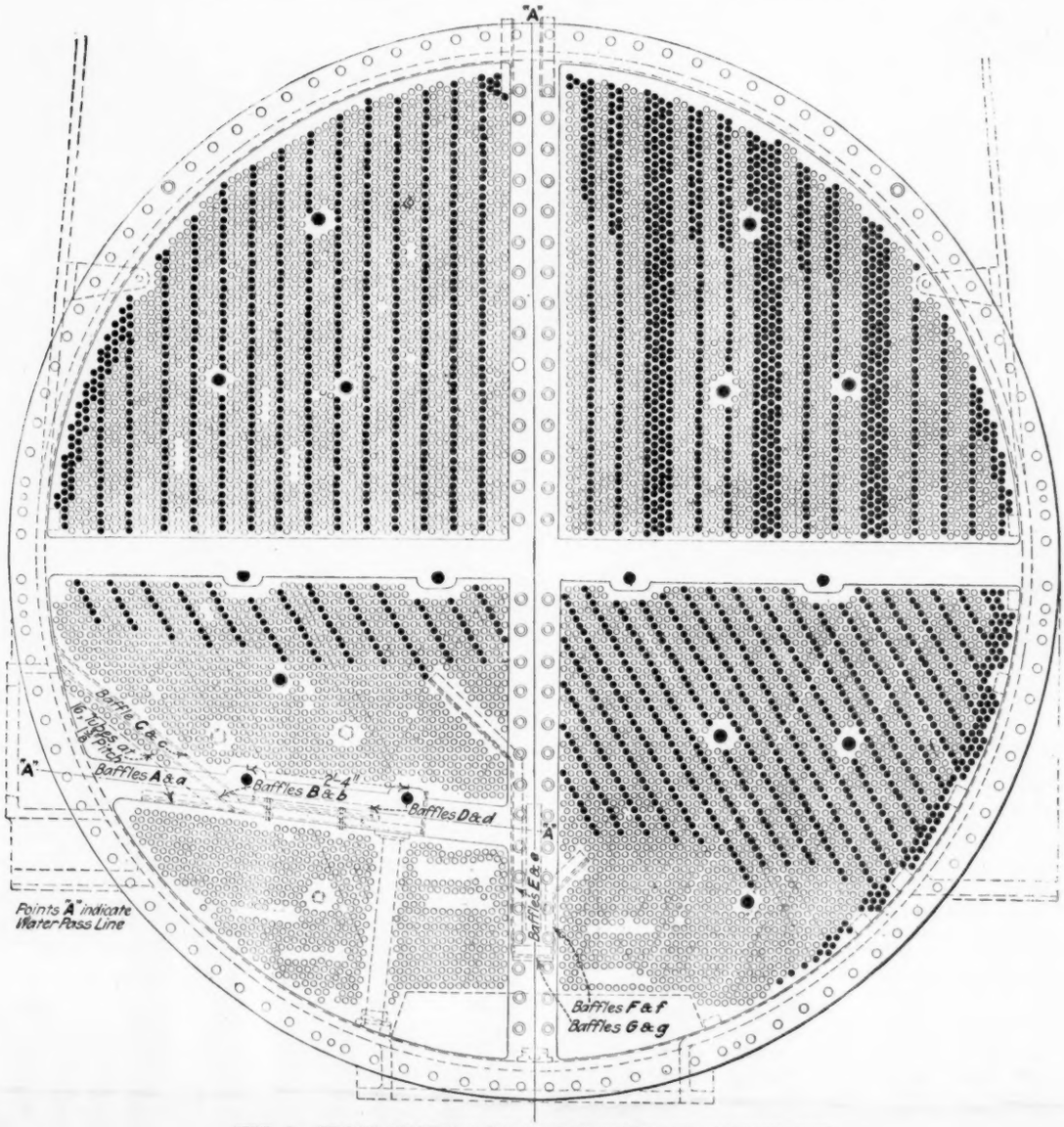


FIG. 8. CROSS-SECTION THROUGH SURFACE CONDENSER

r.p.m., and fitted with bronze impellers. The condensate is discharged into what is known as the cold end of the boiler-feed tank, as will be explained later.

Circulating Water

Circulating water is supplied to each condenser by a motor-driven single-impeller double-suction volute pump. The motor is of the three-phase slip-ring type arranged for a 15-per cent. speed variation, the maximum speed being 400 r.p.m. During the period of the year when circulating water has a high temperature the pump will be operated at the highest speed and will deliver about 40,000 gal. per min. When the water temperature is low, the pump will be operated

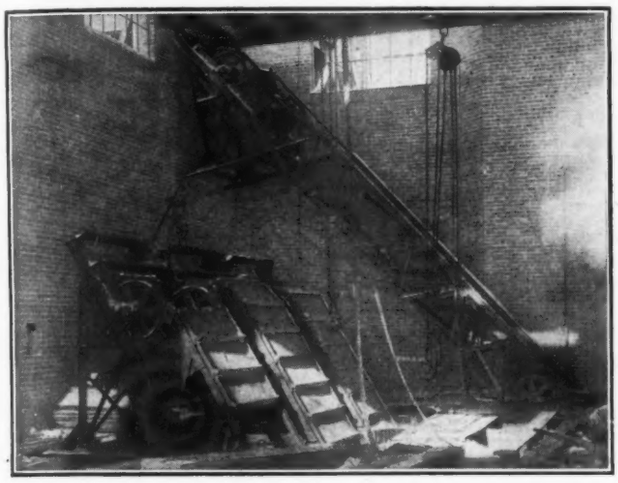


FIG. 9. REVOLVING SCREEN UNDER ERECTION

at the lower speed and the quantity will be proportionally reduced. The temperature of circulating water varies with the season from 34 deg. to 76 deg. F.

The circulating water enters the property through an open cut shown in the plan in Fig. 2 and then flows through a concrete tunnel to the screen house. This tunnel has a free section 9 ft. 3 in. high by 10 ft. wide, and when it is supplying water for all of the units in the finished plant under the lowest water conditions on record the water velocity will be just under 8 ft. per sec. In obtaining this figure the additional units are assumed to be larger than those at present installed.

From this section of the tunnel the water flows into a sort of funnel-shaped enlargement which leads it to the screens. These are of the traveling variety and are similar to screens already installed in the Northwest station in Chicago and at the Delray station in Detroit. They consist of woven-wire panels fastened to the links of an endless chain, the lower end of the loop thus formed projecting down to the bottom of the water channel. The construction is shown in Fig. 9, which is a reproduction of a photograph taken in the interior of the screen house before it was completed.

When a screen becomes fouled, the working side of the loop is drawn up and over the upper guide shaft, its place being taken by what was previously the back side of the loop. This operation brings the fouled screen panels under a wash pipe which washes the fouling material into a channel which carries it to the overflow canal. The screens are operated by motors and are started and stopped periodically as required. Their constant movement is necessary only under exceptional conditions. Provision is made for returning water from the overflow tunnel into the intake to assist in keeping the screens and tunnel clear of ice during cold weather.

After passing through the screens the circulating water is turned through a right angle and flows down the length of the house in a tunnel, which is 15 ft. wide and 9 ft. 3 in. high. Water is picked up by the circulating pumps through large angle fittings incased in the side wall of this tunnel.

The water passes in the condenser are rather unusual. Entering water passes through the tubes occupying one vertical half of the condenser plus those inclosed by the air box, or cooler, at the lower end of the other vertical half. The water then returns through the tubes above the air cooler and overflows through a large cast-iron nozzle and elbow which points downstream in the overflow canal.

Air and noncondensable vapors are removed from a header space in the cooler by means of a 35x39-in. rotative dry-vacuum pump. This pump is arranged for two-stage operation in one cylinder, one end of the cylinder serving practically to load the other. A direct-current motor, with the armature mounted on the crankshaft, drives the unit. The normal speed of the pump is 100 r.p.m., but the motor is arranged for a speed reduction of 40 r.p.m., and seldom need be operated at or near its maximum.

It will have been observed that all of the auxiliaries thus far mentioned are motor-driven. As a matter of fact, this is true of all the auxiliaries in the plant with the exception of the boiler-feed pumps. The latter are 1200 gal. per min., four-stage, double-suction, centrifugal pumps, driven by 350-hp. steam turbines at 2000 r.p.m.

The motor-driven auxiliaries—all or any of them—may be operated with power taken from the system bus, or they may be operated with power taken from 1000-kw. turbine-driven alternators, known as house-service alternators. In every case the arrangement is used which, in conjunction with the other adjustments described below, will give the best heat balance for the station under the conditions at the time existing.

Barometric Condenser Used as Open Feed-Water Heater

What may be called the house-service system is shown diagrammatically in Fig. 10. It is really a development of a method long used in both marine and stationary practice, in which a feed-water heater is operated under vacuum. In the present instance the wet-vacuum pump of each main turbine unit discharges into one end of a large tank, known as the boiler-feed tank. A centrifugal pump draws its water from the same end of this tank and discharges it into the head of a barometric condenser. The relatively cold condensate is picked up by the second pump before it has time to mix with the mass of water in the tank and serves very well as injection water for the barometric condenser. The house-service alternator turbine and the boiler-feed pump turbine exhaust into this barometric condenser, so that the condensate from the main unit takes up all the heat of the auxiliary steam. The foot of the barometric condenser is immersed in the other (or hot) end of the boiler-feed tank. The mixture is there picked up by the boiler-feed pump and delivered to the boilers.

The barometric condenser is therefore the equivalent of an open feed-water heater in which exhaust steam from

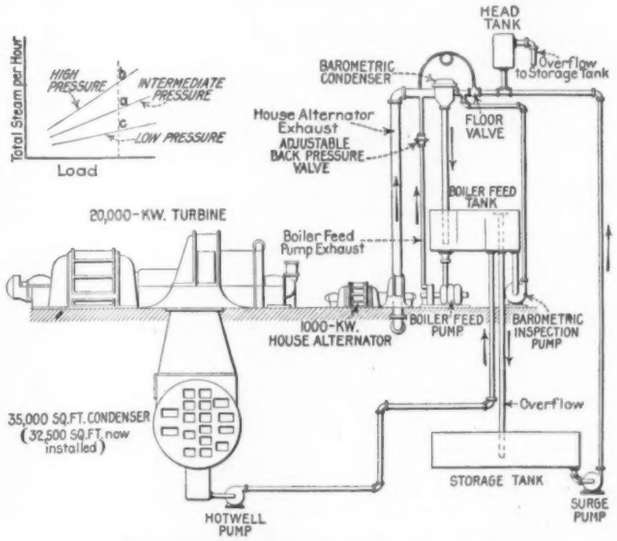


FIG. 10. HOUSE-SERVICE SYSTEM

auxiliaries mixes with and heats the condensate from the main units, the mixture passing to the boilers as feed water. This condenser, however, offers possibilities not possessed by the ordinary open heater in that it is capable of maintaining a low back pressure, if this is desired, or can be operated at any pressure between this and atmospheric. This property, taken in conjunction with the great variation of the auxiliary turbine water rate with variations of back pressure, serves to give great flexibility of control of the station heat balance.

Control of Feed-Water Temperature

This is shown diagrammatically in the upper left-hand corner of Fig. 10. The straight lines represent total steam consumption of the house alternator turbines for the entire

range of load at different back pressures. Assume that at some particular time, with a given load and vacuum on the main unit, the load on the house alternator has the value indicated by the vertical line and that the back pressure is that corresponding to the middle steam consumption line as at a. If the feed-water temperature is too high, it can be lowered by decreasing the back pressure and reducing the steam consumption to some such value as that shown at c. In this way the feed-water temperature can be accurately controlled, just enough auxiliary exhaust being made available to give the desired temperature.

The variation of the back pressure is obtained by means of a back-pressure valve in the exhaust line from the boiler-feed pump turbine. If, under given constant conditions, this valve is partly closed, the back pressure on the boiler-feed pump turbine is increased and its steam consumption for the same load is correspondingly raised. This, however, means that more steam enters the barometric condenser and, with a constant quantity and temperature of circulating water (main condensate), the temperature and pressure in the barometric condenser must rise. This, in turn, means higher back pressure on the house alternator turbine, and it delivers more steam, thus still further raising the temperature.

Under certain conditions this interchange may result in a cumulative temperature rise, ending only when the pressure in the barometric condenser becomes equal to that of the atmosphere and the auxiliary exhaust blows to waste. To prevent such an occurrence the flood valve shown in Fig. 10 is provided. This is automatically opened whenever the temperature of the steam entering the barometric condenser exceeds a predetermined value. When it operates it admits comparatively cold water from the storage tanks, adding it to the normal supply of injection water entering the condenser and thus bringing the temperature down quickly. It then automatically shuts off. Under poor conditions of adjustment this valve would continue to open and shut periodically until all of the water in the storage tank and boiler-feed tank had been heated to about 212 deg. F., but such a contingency is not probable, because this would take a long time and the watch engineer would make the necessary readjustments before the valve had acted many times.

The house alternator, boiler-feed pump and barometric injection pump are all grouped under the gallery shown at the right-hand side of the turbine room in Fig. 4. The natural position for the watch engineer is at the same place, so that continuous observation of this apparatus is readily obtained. An auxiliary gage board containing instruments showing critical temperatures, pressures and quantities is located within easy view, and the results of all adjustments are readily seen.

Advantages of House-Service System

This method of operating the auxiliaries appears complicated when described on paper, but it has proved to be simple in practice and easy to handle. It possesses the following advantages, which should be compared with methods more commonly used:

1. The one great advantage of steam-driven auxiliaries is retained because exhaust steam is available for feed-water heating.
2. The quantity of auxiliary exhaust can be fitted to the ability of the feed to absorb it.
3. All the advantages of motor drive are obtained.
4. Up to the ability of the feed water to absorb steam, the power used by the motor-driven auxiliaries is produced at a thermal cost practically equal to that obtained in the case of steam-driven auxiliaries.
5. Since the feed-water heater is normally operated under a vacuum, the feed-water temperature is readily maintained at a value which will give ideal economizer operation.
6. Because of the vacuum maintained in the feed-water heater, air is readily removed from the feed water just before it enters the boiler-feed pumps. In practice there is no reabsorption of air by the condensate between the main condenser and the boilers.

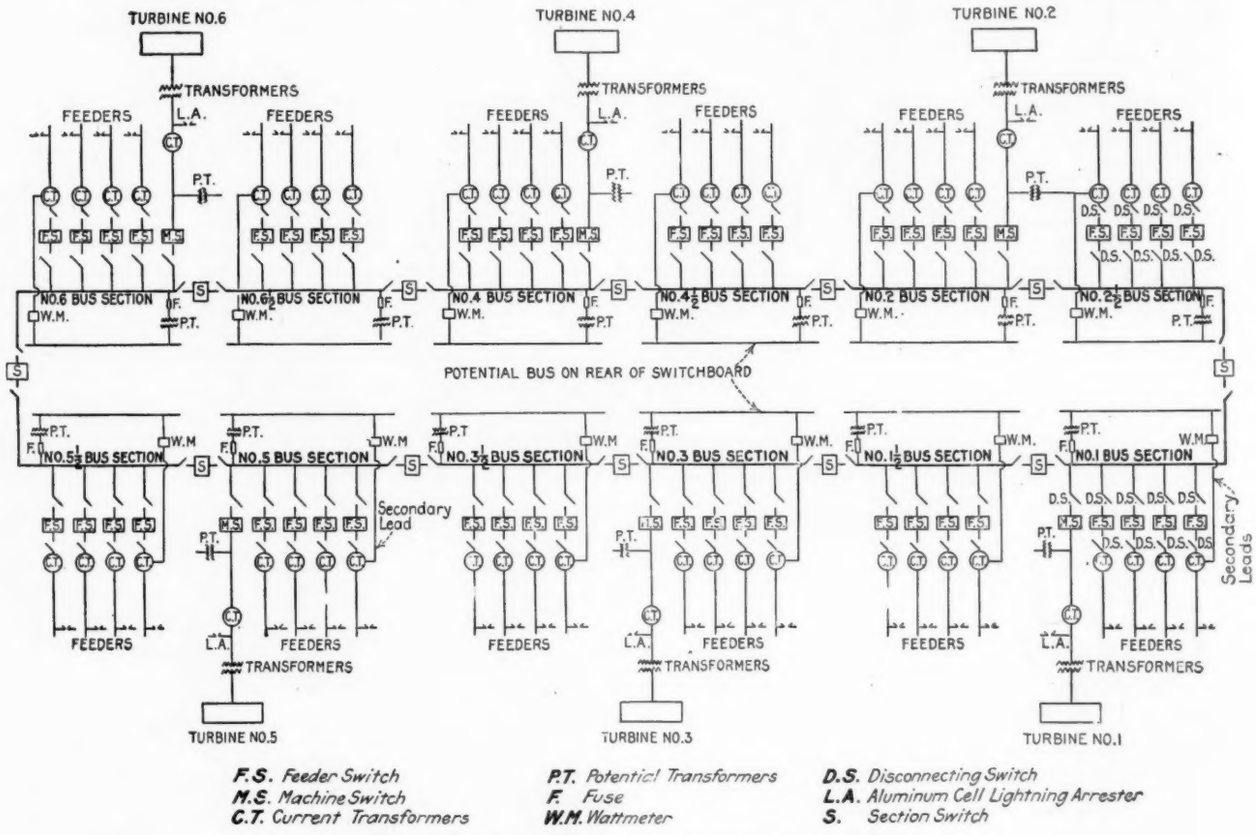


FIG. 11. WIRING DIAGRAM OF 24,000-VOLT BUS

Make-Up Water Distilled

Another unusual feature is the provision for the distillation of all make-up water. Experience at Delray has shown that the quantity of make-up required may be readily held down to 1.5 or 2 per cent. Under such conditions the apparatus required for distillation is small and the cost is negligible in comparison with the cost of boiler labor saved. The evaporator installed has a capacity of 12,000 lb. of vapor per hr. and is heated by high-pressure steam. The vapor formed in it passes directly to the barometric condenser, in which it mixes with the auxiliary exhaust and thus becomes part of the feed water.

Many cases of boiler pitting and corrosion which are recorded in engineering literature have been attributed to

the use of pure water, and the presence of a small quantity of scale-forming material has therefore been regarded as desirable. Most authorities now seem to believe that pure water is not responsible for such damage to good boiler metal, but that the blame is to be laid on small quantities of atmospheric carbon dioxide dissolved in what is assumed to be pure water.

In the Connors Creek plant the feed-water heating and storing system has been so designed as to prevent the absorption of air, so far as prevention is readily possible. Should experience show that the provisions made are inadequate to insure safe boiler operation, there are several simple remedies. The simplest is probably the use of a small quantity of an alkaline salt, experience having demonstrated that if the water shows a mere trace of alkalinity it is apparently noncorrosive.

Another innovation in this station is the very complete provision for the turbine-room ventilation, principally through louvers above the air washer shown in Fig. 4. This air, after being washed if necesssary, passes down through the turbine room, picking up part of the heat lost by the steam apparatus. Ultimately it is drawn into the generator, picks up the heat representing the losses therein, and is discharged through a duct below the turbine-room floor. This duct carries the heated air into the pipe gallery in which the stoker blowers are located. On its way to the blowers the air washes the outside of the covering of all steam pipes, so that it also picks up the heat which these surrender to the surrounding atmosphere. In this way a large fraction of these unavoidable losses is conserved by being delivered to the boiler furnace, so that just that much less heat need be supplied by fuel.

The electrical end of the plant also contains several unusual features. Notably, the generator leads are tied solidly to transformers which have a 1 to 5 ratio. These step the voltage up to 24,000, at which voltage all metering and switching is done. One of these transformers is shown to the left of the turbine room in Fig. 4. There are three 8333-kv.-a. single-phase water-cooled transformers per turbine.

A semi-diagrammatic layout of the complete electrical system is given in Fig. 11. The turbines will be arranged in one straight row when all are installed, but the bus is built in the form of a loop, as shown in the figure. Section

PRINCIPAL EQUIPMENT OF CONNORS CREEK PLANT OF THE DETROIT EDISON COMPANY

(Data are for part of plant already installed consisting of two main units and auxiliaries.)

No.	Equipment	Kind	Size	Use	Operating Conditions	Makers
4	Boilers	Stirling Type "W"	2365 hp	Generate steam	225 lb. pressure, 200 deg. sup. at 200% rating	Babcock & Wilcox Co.
8	Stokers	Under-feed sloping fuel bed	13 retorts each	Serve boilers	Driven by D. C. motors and Morse chain	American Engineering Co.
3	Pumps	4-stage impeller type turbine	1200 gal. per min.	Feed boilers	Steam turbine driven	Jeanesville Iron Works
6	Blowers	Double conoidal	74,000 cu.ft. per min. against 6½ in.	Air to stokers	D. C. motor driven	Buffalo Forge Co.
2	Conveyors	Pan conveyor	120 tons per hr.	Coal from car or receiving hopper to crusher	D. C. motor drive, angle 27 deg., 49 min	Link-Belt Co.
2	Conveyors	Overlapping bucket	120 tons per hr.	Coal from crushers to bunkers	A. C. motor drive	Link-Belt Co.
2	Crushers	Four roll	120 tons per hr.	Crush coal	A. C. motor drive	Orton & Steinbrenner
1	Scale	Track	50 ft., 150 ton	Weigh cars		Fairbanks Morse & Co.
4	Feed water regulators	Copes		Regulate water feed to boilers		Northern Equipment Co.
2	Turbo-generators	Horizontal, 9-stage steam end	25,000 kv.-a.	Main generating units	60 cycle, 3-phase, 4600 volts, 1200 r.p.m.	General Electric Co.
2	Turbo-generators	Horizontal	1,000 kw	Power for auxiliary machinery	60 cycle, 3-phase, 250 volts	General Electric Co.
1	Balancer set		12½ kw	125 volts current used in speed control of stoker motors and used for clocks	3600 r.p.m., 250/125 volts, 1800 r.p.m.	General Electric Co.
2	End-cell charging sets		60-kw		240 volts, A. C., 3-phase motor, 150 volts, D. C. generator	General Electric Co.
6	Transformers	Single-phase, water-cooled	8330-kw., 4800 to 24,000 volts	Step-up output of main units		General Electric Co.
1	Transformer	Water cooled, three-phase	1000-kw., 23,000 to 230 volts	House service		General Electric Co.
1	Oil drier	20 chamber	30 gal.	Drying transformer oil	Intermittent	General Electric Co.
1	Storage battery	Exide type G 39	140 cells	Emergency lighting, excitation and auxiliary drive		Electric Storage Battery Co.
1	Air compressor	Two-stage variable volute	840 cu.ft. per min., 18½ x11x18 in., 150 r.p.m.	Air for cleaning, shop use, etc.	Driven by 150 hp	Laidlaw-Dunn-Gordon Co.
1	Air compressor	Single-stage	113 cu.ft. per min., 8x 8 in., 250 r.p.m.	Auxiliary to large pump	Driven by squirrel cage motor	Ingersoll Rand Co.
1	Crane	Traveling girder type	75 ft., 6 in. span, 65 ft. lift main hoist 100 tons	Turbine room service	All a.-c., 3-phase motors	Northern Engineering Works
1	Crane	Girder type, hand power traveling	14 ft., 5½ in. span, 25 ft. lift, 25-ton cap.	Turbine room gallery service	Hoist a.-c., 3-phase	Northern Engineering Works
1	Crane	Single girder hand power traveling	20 ft., 1-in. span, 3-ton cap.	Machine shop service		Northern Engineering Works
1	Crane	Single girder hand power traveling	17-ft., 4-in. span, 3-ton cap.	Pump room crane		Northern Engineering Works
1	Crane	Hand power traveling	8-ft. span, 17-ft. hoist, 1-ton cap.	Switch house crane		Northern Engineering Works
3	Motor-generator sets		750 hp., 720 r.p.m. motor, 500 kw., 250 volts d.-c. generator	D. C. Auxiliary drive		General Electric Co.
2	Condensers	Surface	35,000 sq.ft.	Condenser main exhaust		Henry R. Worthington
2	Pumps	Double suction volute	42-in., 36,000 to 40,000 gal. per min.	Circulating water—main condenser	16 ft. head, 360 to 400 r.p.m.	Henry R. Worthington
4	Pumps	2-stage horizontal	6-in., 702 gal. per min.	Main condenser, hotwell pump	100 ft. head, 1200 r.p.m.	Henry R. Worthington
2	Pumps	Rotative dry vacuum, 2 stage in one cylinder	35x30-in.	Main condenser air pump	Variable speed, D. C. motor drive, max. 100 r.p.m.	Laidlaw-Dunn-Gordon Co.
2	Condensers	Barometric	20-in.	Heater condenser	Variable vacuum	Alberger Pump & Cond. Co.
2	Pumps	Horizontal, single-stage rotative dry vacuum	10x14-in.	Air pump for barometric condenser		Alberger Pump & Condenser Co.
2	Pumps	Single-stage volute	4-in.	Circulating water for bar. condenser	Variable speed d.-c. motor drive	Alberger Pump & Condenser Co.
1	Evaporator	Live steam tubular	12,000 lb. distilled water flow	Make up feed water		Swenson Evaporator Co.
2	Pumps	2-stage centrifugal	500 gal. per min.	General service	80 lb. discharge pressure, 15 ft. suction lift	Buffalo Steam Pump Co.
2	Pumps	Double suction, single-stage	100 gal. per min.	Surge pump	95 ft. total head	A. S. Cameron Steam Pump Works
4	Pumps	Double suction, single-stage	700 gal. per min.	Surge pump	105 ft. total head	A. S. Cameron Steam Pump Works
2	Pumps	Turbine type form stage centrifugal	60 gal. per min.	Sanitary	50 lb. discharge and 20 ft. suction lift	Dayton Turbine Pump Co.
2	Elevators	Passenger and freight push button automatic control	3000-lb. capacity, plus weight of car 150 ft. min. av. sp.	Boiler room and switch gallery service	Boiler room elevator total travel 94 ft., 6 in., switch gallery elevator—total 63 ft. 8 in.	The Haughton Elevator & Machine Co.

switches are provided between bus sections corresponding to each turbine, and each of these sections is in turn divided approximately into halves, thus localizing the effect of breakdowns to the greatest feasible extent. These section switches are nonautomatic.

All switches are mounted in separate compartments on the floor immediately above the bus structures. The machine, section and feeder switches are of the motor-operated, oil-break type provided with lock-type disconnecting switches on both sides, so that they can be completely "killed" for cleaning or repair. The doors on the oil switch and disconnect compartments are automatically locked by the closure of the oil switch.

On the floor above the switch gallery are located the storage battery (for auxiliaries, switches and signals), the switchboard and small electrical auxiliaries, such as a balancer set, battery-charging boosters and a control motor-generator. The switchboard is located at what will ultimately be the center of the length of the power house and is built in two sections, arranged back to back. The section facing the turbine room contains only the control switches and indicating instruments, while the rear board contains the integrating instruments and protective relays. All electrical equipment, with the exception of the motor-driven auxiliaries, is controlled from this gallery. The distant-control switches for these are located to the left of the turbine foundation. The auxiliary starting push buttons and the controllers for variable-speed motors are located at the most convenient points, generally near the motor.

The switch-gear current for all apparatus handled from the main switchboard is supplied by the 25-kw. control motor-generator set mentioned. This floats on a section of the storage battery, thus insuring continuity of service on the control.

In explanation of the departure from recent practice in the omission of protective reactances, attention should be called to the fact that the inherent reactance of the apparatus connected to the busses, together with the nature of the bus structure, is such that no protective reactances are deemed necessary. Provision has been made in the bus structure for the installation of additional supporting insulators opposite those already in place when the connected generator capacity becomes such as to demand additional rigidity, also for feeder reactances if changes of distribution methods later should make these desirable.

Each turbine is normally excited at 250 volts by an exciter mounted on an extension of the generator shaft. In ordinary operations the armature of the exciter supplies the generator field directly, voltage control being effected by a motor-driven dial switch on the exciter's field rheostat. The generator field may also be excited from the direct-current house-service bus, in which case it is controlled by a motor-operated rheostat in the main field circuit. The house service direct-current bus which supplies the direct-current auxiliaries and the emergency excitation is supplied by motor-generator sets, one to each station unit. The station storage battery also floats on this bus, insuring continuity of service.

The use of alternating current motors for some auxiliaries and direct-current for others was determined by the following considerations: For constant-speed motors alternating current was chosen. For speed variation of small range (as for the circulating pump where 15 per cent. variation is sufficient) or of only occasional use (as the crane motors), alternating-current motors with external resistances were chosen, except for the dry-vacuum pumps, where the desirability of being able to start up from a condition of complete shutdown dictated the use of a direct-current motor backed up by the storage battery. For long ranges and exact adjustment of speed variation, such as are required by stokers and blowers, direct-current motors were chosen. Of course, the common practice was followed in using direct-current and storage-battery reserve for switch gear and signals.

Why Economizers Were Not Installed

The fact that economizers were not installed in this plant despite the high thermal efficiency striven for has caused considerable comment and has been the source of many questions. Failure to install such apparatus must not be understood as a declaration of disbelief in its efficiency. It is, however, felt that the cast-iron tube economizer as now built and operated at full boiler pressure is not a proper piece of apparatus for installation in a modern high-pressure plant. Because of the high efficiency attainable with the large boilers it was deemed advisable not to install economizers until such a time as a more satisfactory type or a more acceptable method of operating is produced.

Recently the Connors Creek plant has been put in operation and thoroughly tested out. Small troubles such as would be expected with a new and radical design of this sort have been met, but on the whole the plant has operated very smoothly. The operating record shows that the thermal efficiency of the plant will be about as high as was expected when it was laid down. The coal consumption per kilowatt-hour during the first two months of operation was considerably lower than the record performance of the Delray plant, and it is natural to expect that it will be further decreased as the operating methods are improved.

Attention Sales Manager

The following circular letter, issued by the Bureau of Foreign and Domestic Commerce, Department of Commerce, is reprinted at the request of E. E. Pratt, chief of that bureau.

I should like to ask you the following question: "Are you aware that the United States Government through this Bureau publishes a daily paper which transmits valuable trade information concerning market conditions in all parts of the world to American manufacturers and merchants?"

As an American business man, you cannot afford to overlook a publication which secures information from three hundred consular officials, located in every part of the world, which contains special articles prepared by commercial attachés and agents of the Department of Commerce, stationed at the most important centers of foreign trade, and which gives to the American manufacturer a daily list of firms in foreign countries anxious to buy American goods and represent American manufacturers. It also contains a complete daily record of what the United States Government wants to buy or construct.

Daily "Commerce Reports" is a Government publication which every American business man should read with his morning mail. It furnishes him with a daily summary of the market conditions and prices of different lines of industry in the world's markets, and contains notices of current changes in the tariffs and trade-mark laws of foreign countries. It shows you from day to day what your competitors in other countries are doing.

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Daily "Commerce Reports" mean knowledge and additional trade for you.

Daily "Commerce Reports" will be delivered to your office by mail every morning for one year for the nominal sum of $2.50. If you are not already receiving these reports, I strongly advise that you subscribe by sending a money order or check to the Superintendent of Documents, Washington, D. C., or to the nearest branch office of the Bureau of Foreign and Domestic Commerce.

New Jersey State License Board Complete

Joseph F. Scott, of Morristown, N. J., has been appointed examiner for the steam-engine and boiler operators' license bureau, Trenton, N. J. This completes the board of three members, the others, A. L. Case and M. J. Hickey, having served quite some time.

Mr. Hickey will have charge of the first district, made up of Bergen, Hudson, Morris, Passaic and Hudson counties; M. Case will care for the second, comprising Essex, Hunterdon, Mercer, Middlesex, Monmouth, Somerset, Union and Warren counties; Mr. Scott takes the southern end of the state, or Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Ocean and Salem counties.

Interpreting Massachusetts' New License Law

In response to inquiries by George C. Neal, acting chief of the District Police, Attorney-General Attwill of Massachusetts has interpreted the Engineers' and Firemen's License Law for 1915 as regards several points at issue. The first point was the definition of what constitutes a manufacturing plant within the meaning of Section 1 of the act. This provides that in manufacturing plants an unlicensed person may operate, under a licensed person on duty, a simple non-